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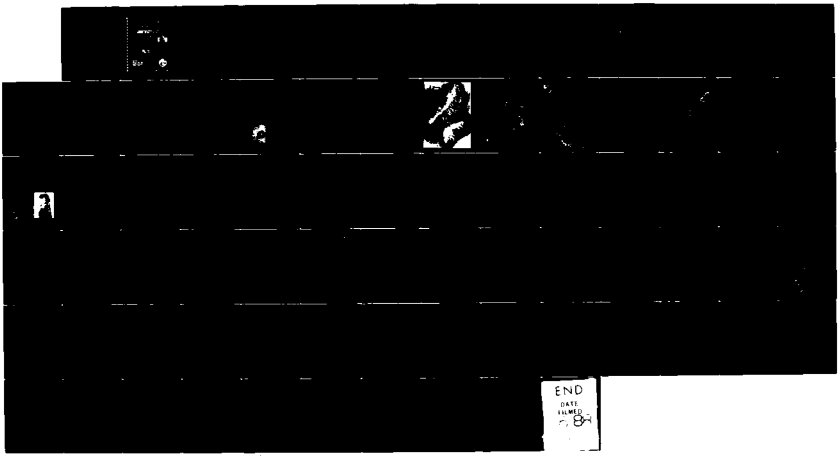

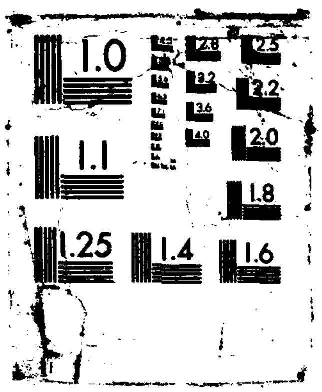
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AEAS Report Number 13

[illegible]ering Report on the [illegible] Replacement Source

FINAL REPORT

by

Joseph L. Collins

September 1987

Prepared for:

[illegible]

AEAS Report Number 13

Engineering Report on the Kaneohe Replacement Source

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ABSTRACT

In 1978, an HX-137 acoustic source was installed off Kaneohe Bay, Hawaii. In 1980, the HX-137 was replaced by another HX-137. In 1986, the HX-137 failed after being inoperative for more than 2½ years due to cable failure; the transducer failed about 30 days after the cable replacement.

A brief engineering analysis was conducted to evaluate and select the preferred solution for replacing the failed transducer. This analysis recommended a moving coil projector, based on acoustic performance, timeliness and cost.

The moving coil projector was designed, fabricated, calibrated and installed in 90 days. The ocean engineering design was developed to support an easy and quick replacement procedure so that an annual recovery and exchange of transducers, for purposes of refurbishment, could be readily and economically carried out; the design is based upon the premise that transducers will be refurbished on a 12-month schedule.

The source is being operated on a continuous basis, and is meeting all performance objectives for the various users.

This document describes and discusses the transducer and its parameters, the site characteristics, and the ocean engineering design effort. This document is written to provide a data base for users, and to aid in future improvements/changes.

This project was managed by ONR Code 132 (AEAS) for SPAWAR Code 180.

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LIST OF ILLUSTRATIONS

ENGINEERING REPORT — KANEOHE REPLACEMENT SOURCE

1. INTRODUCTION AND BACKGROUND

The replacement for the failed Kaneohe acoustic source was developed to meet both acoustic objectives and a 3-month time constraint; the source was installed in approximately 90 days (as per schedule) after the initial go-ahead was given. The new source is a Model KN-1, manufactured by ARGOTEC, Inc., and was developed to replace the HX-137 bender bar transducer. The KN-1 is a moving coil transducer designed to operate over a 50 to 300 Hz acoustic band at a maximum source level of 190 dB re one micro-pascal at one meter, over the band. This report will discuss the history, engineering design and use of the Kaneohe source.

The prior use of the Kaneohe source and the recent history of the system failure is well documented in a memo written by Jim Pugh (NOSC San Diego), and incorporated into this report as Appendix A. The existing HX-137 source was designed to meet the acoustic requirements in approximately 1977. Since then, requirements have changed and the KN-1 source does reflect the new requirements in both operating bandwidth and source level.

The replacement issue was presented to AEAS (ONR Code 132), and an engineering study was carried out to determine the performance, cost, time, and ocean engineering alternatives. The results of this analysis were presented in a memorandum titled: "Engineering Analysis to Evaluate Alternative Kaneohe Sources" by Joe Collins, and is attached to this report as Appendix B. During this analysis, consideration was given to refurbishing the failed source, modifying or building a new HX-231 bender bar source, or building a moving coil source. The combination of cost, urgency and acoustic performance objectives drove the solution toward a new moving coil source. Appendix C is a brief management plan that outlined the project implementation, and guided the schedule and design decisions.

A key factor in being able to meet the 90-day constraint was the availability of a magnet of adequate size to support the electrical/acoustic power requirements. This magnet was available at ARGOTEC, Inc., because of their continuing efforts to build large moving coil transducers.

A second important factor was the ocean engineering impact upon the design, since long-term installation and ease of refurbishment were critical factors in the cost/performance decision. TRACOR Marine (Fort Lauderdale, Florida) was selected as the ocean engineering firm to support the system design and installation planning.

A third important factor was the site properties, which impacted both the design and installation plans. Considerable help was provided by both NOSC San Diego and its Hawaii Laboratory. In particular, Harold Chalmers and Lance Remick (in Hawaii) were very helpful in developing the system and environmental data base to support the design phase. Jim Pugh (NOSC San Diego) provided the necessary system history, identified issues and people, and provided excellent help in defining the real acoustic performance objectives.

The list of individuals who were involved in helping to make the original assessment, as well as those involved in the design and installation planning, is included in Appendix D for reference purposes.

As has probably been noted, one objective in developing this report is to identify the audit trails through the planning, construction, and installation phases. Future users of the system will have adequate documentation and names of individuals to make "how to start" questions easy.

The following sections will discuss the source design criteria, the existing driver amplifiers and underwater cables, and the installation and recovery/refurbishment guides. IT IS IMPORTANT TO NOTE THAT THIS SOURCE WAS DESIGNED UPON THE PRESUMPTION THAT A SECOND SOURCE WILL BE ACQUIRED, SO THAT ANNUAL REFURBISHMENT IS ROUTINELY ACCOMPLISHED.

2. SOURCE DESIGN

The performance specifications were developed in response to the major users, with the principal requirements indicated below.

- Operating Bandwidth: 50 Hz to 300 Hz
- Source Level: up to 190 dB re micro-pascal, flat over the band within ± 3 dB
- 600-foot operating depth; long term operation
- Operate with 6 miles of cable

The transducer is a moving coil design with two phase opposed pistons, and utilizes passive depth compensation. The KN-1 transducer is shown in Figure 1. Because of the self-compensating feature, there is a zero pressure differential between the inside of the transducer and the ocean. Air is provided by the reservoir (13) to the inside of the transducer. The piston face (8) is directly connected to the electrical coil (4,5), which is immersed in the magnetic material pole face (1). The piston is allowed to move with the rubber seals (9) at point (10). These seals, actually one seal on each side of the joint, provide mechanical support, and are filled with oil to help minimize any leak paths. Springs (11) help to tune the transducer and provide some support to the piston/coil module.

After the transducer is installed, the air chamber (13) is compressed, and that volume is then filled with water, so that dissipation of the thermal load is also aided by the increased water contact with the magnet/body.

Electrical conductors to the coils (not shown) are also oil filled, and are at zero differential pressure; these leads are connected to the transformer, which is also at ambient pressure. The main signal cable from shore is connected to the transformer input terminals, and the cable is mated to the support platform for mechanical strength. Figure 2 is the electrical circuit diagram connecting the dry-end power amplifier/transformer through the cable to the transducer/transformer unit located on the bottom. Based on the earlier site survey, it was recommended that the dry-end power amplifier and transformer be replaced if the full acoustic power output was desired; some concern was expressed that the amplifier and transformer, which were designed for bender bar transducers, should be replaced as being marginal in capability.

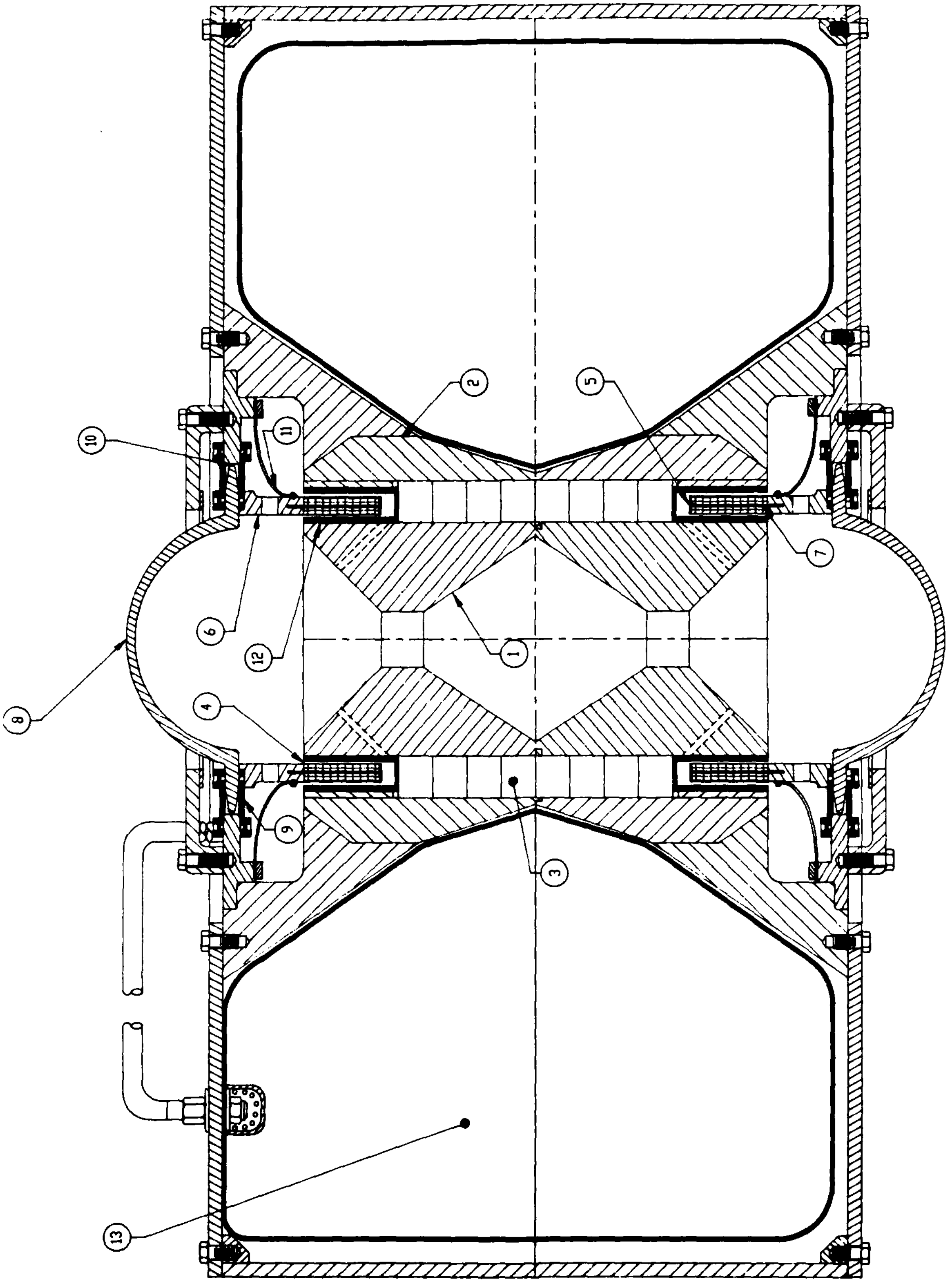


Figure 1. The Model KN-1 Kaneohe Source

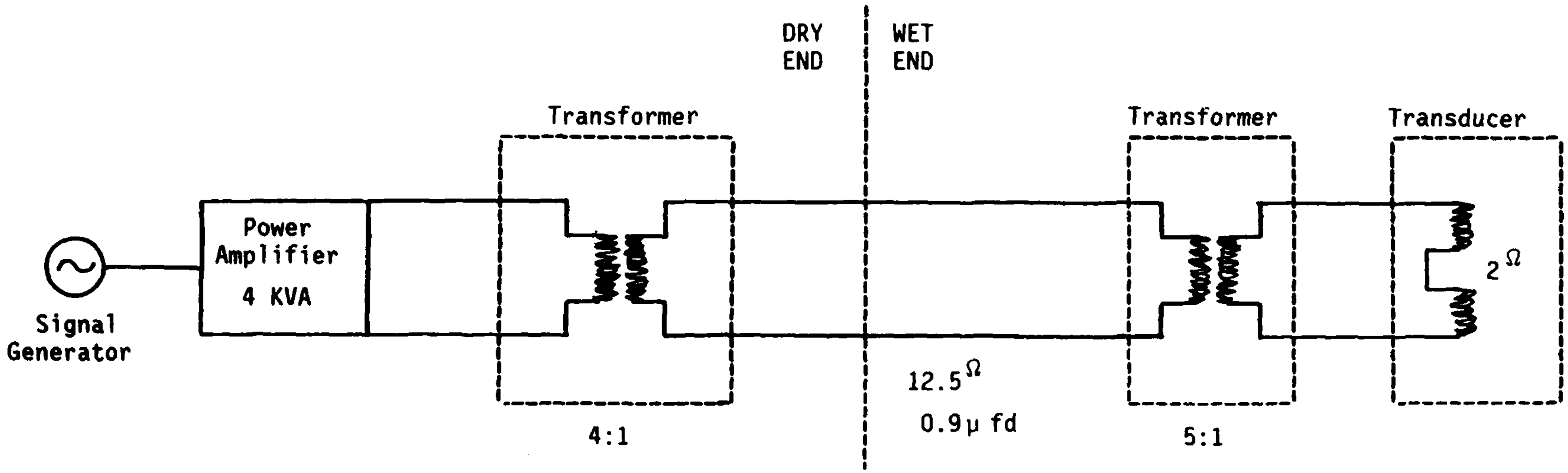


Figure 2. Kaneohe Source Circuit Diagram

During construction, the wet-end transformer suffered insulation damage, and failed after 90 hours of operation. The transformer was replaced with a new transformer; the turns ratio was reduced from 6.45:1 to 5:1, to more closely match the replacement transformer on the dry-end, a 4:1 turns ratio.

3. ELECTRICAL PROPERTIES OF THE SYSTEM

A summary of the various electrical properties is included here for reference purposes. These values are important in determining the actual transmitting current response (TCR) for the system, i.e., how much current into the cable is required for a given source level. These values also determine the amount of power required to drive the transducer to a given level.

Signal Cable:	DC resistance = 12.5 ohms
	Length = 29,000 feet
	Shunt Capacitance = 0.83 mfd
	Impedance: see Figure 6

Output Transformer	: 4:1 turns ratio
Transducer Transformer:	5:1 turns ratio
Transducer Coils	: 2 ohms

The transmitting current response for the wet-end system (i.e., the cable, transformer and transducer) is shown in Figure 3. This curve defines the output sound pressure level as a function of frequency for a 1-amp current input to the cable. This curve combines all the impedance affects that will affect the actual current in the coil windings of the transducer. Figure 4 is the TCR for the transducer without any outside effects, and is the basic response curve. Figure 5 is the measured input impedance to the cable at the dry end, and results from measuring the current and voltage levels into the cable at a given frequency. Table 1 is the measured input impedance values used in constructing Figure 5.

The final curves of importance in predicting the transducer's performance are shown in Figure 6. These two curves define the basic response of the transducer from an electrical viewpoint. The top curve is a measure of the input impedance to the transducer as a function of frequency. This is a plot of the ratio of the drive voltage to the drive current. The peak impedance of 40 ohms occurs at the resonant frequency of just below 50 Hz. The second curve is the phase relationship between the voltage and current drive as a function of frequency passes through resonance. In both cases the frequency scale extends from 10 Hz to 1 kHz, with the impedance scale extending from zero to 40 ohms.

Figure 7 indicates the construction features of the single armored sea cable; the double armored cable has a similar steel wire outer armor, and is used during the first 1,000-foot section from the transducer toward shore. A summary of the major sea cable properties is included in Table 2. Note that the double armor provides the extra strength necessary to recover the source by the signal (sea) cable.

The electro-acoustic properties shown in these tables and curves will provide the necessary data base to change or modify the power amplifier and the drive signal frequency to obtain desired response in output sound pressure level. If changes are made to the cable, or the errors in earlier measurements are noted, then the TCR for the system must be re-developed.

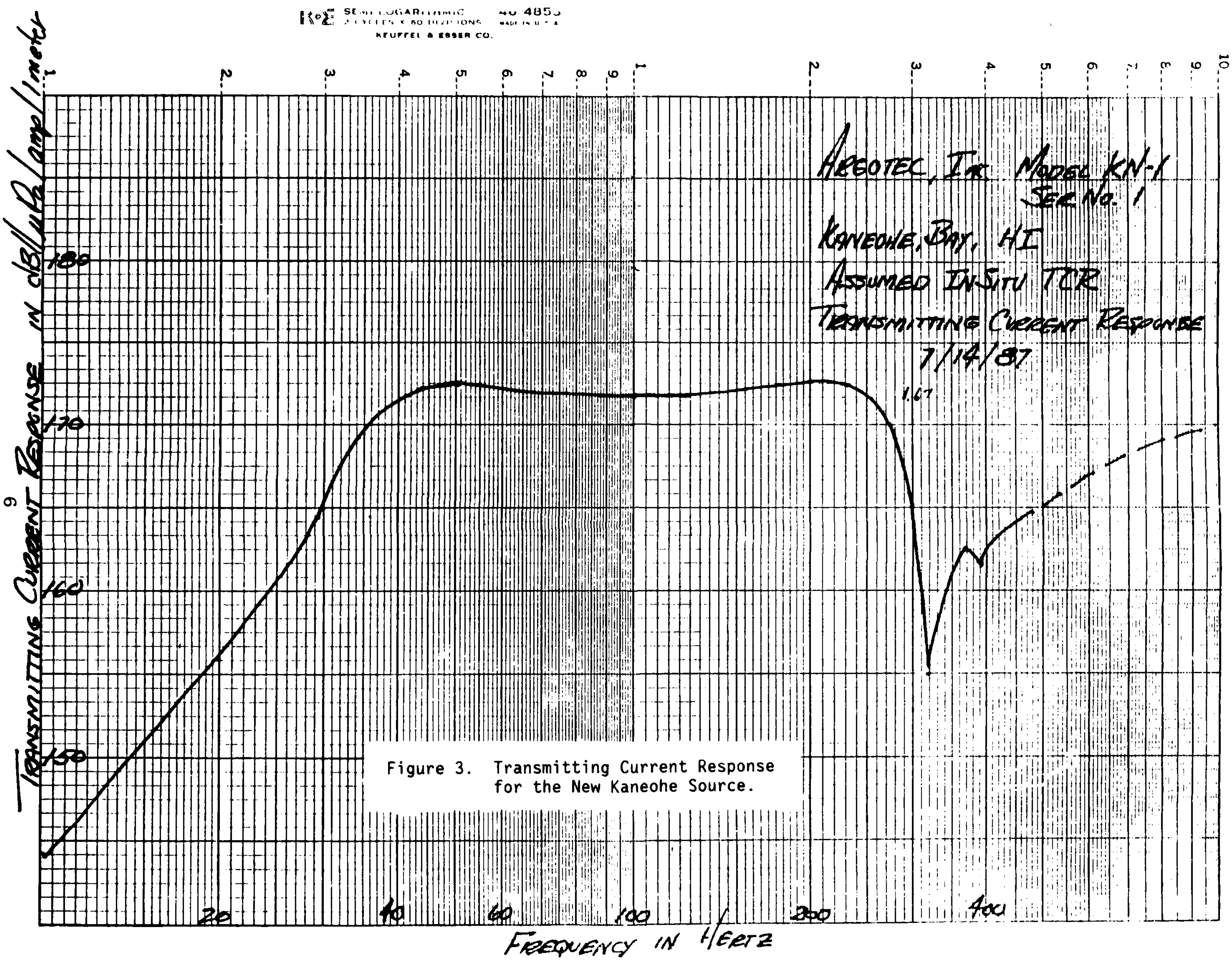
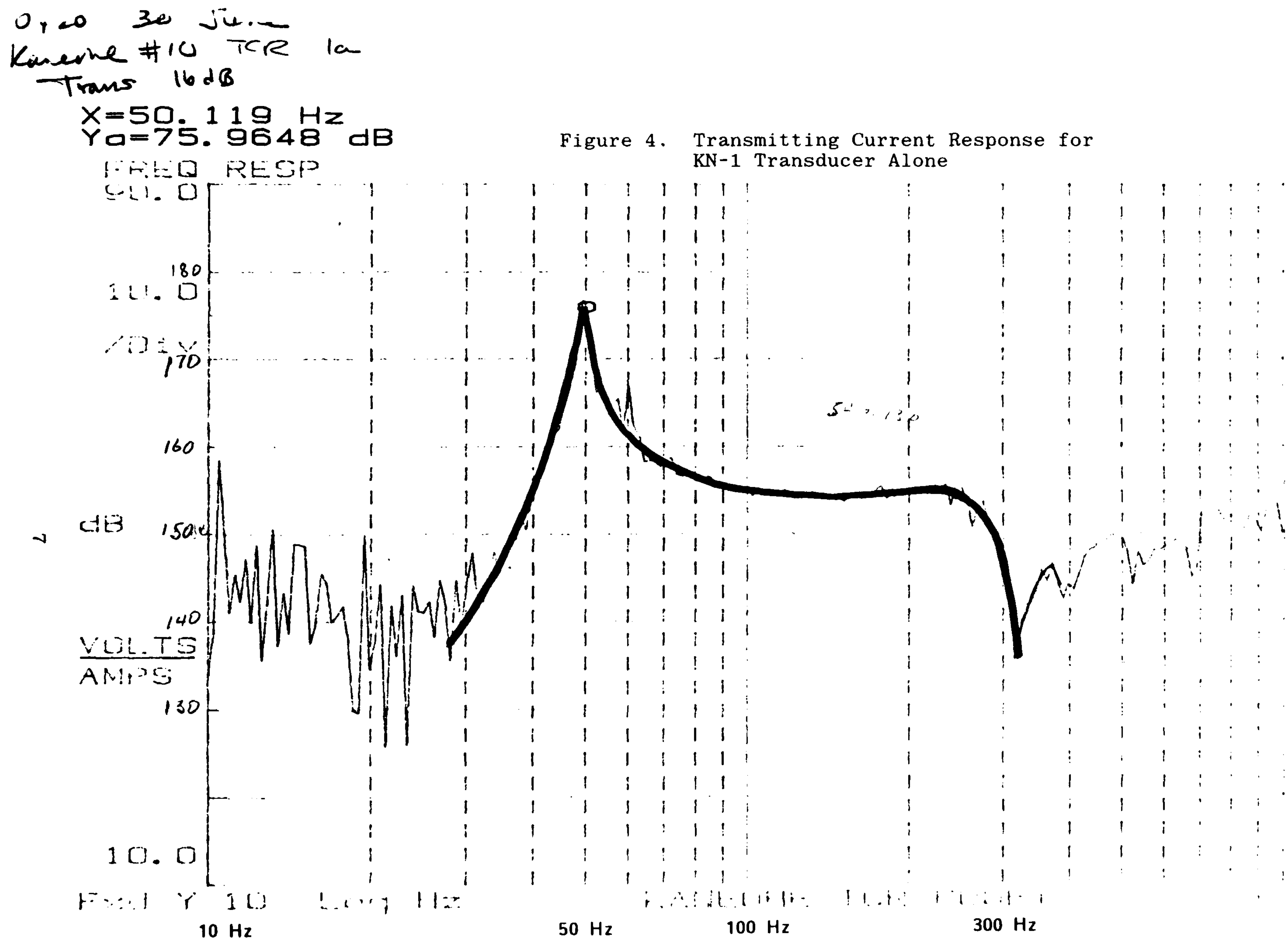


Figure 3. Transmitting Current Response for the New Kaneohe Source.

Figure 4. Transmitting Current Response for KN-1 Transducer Alone



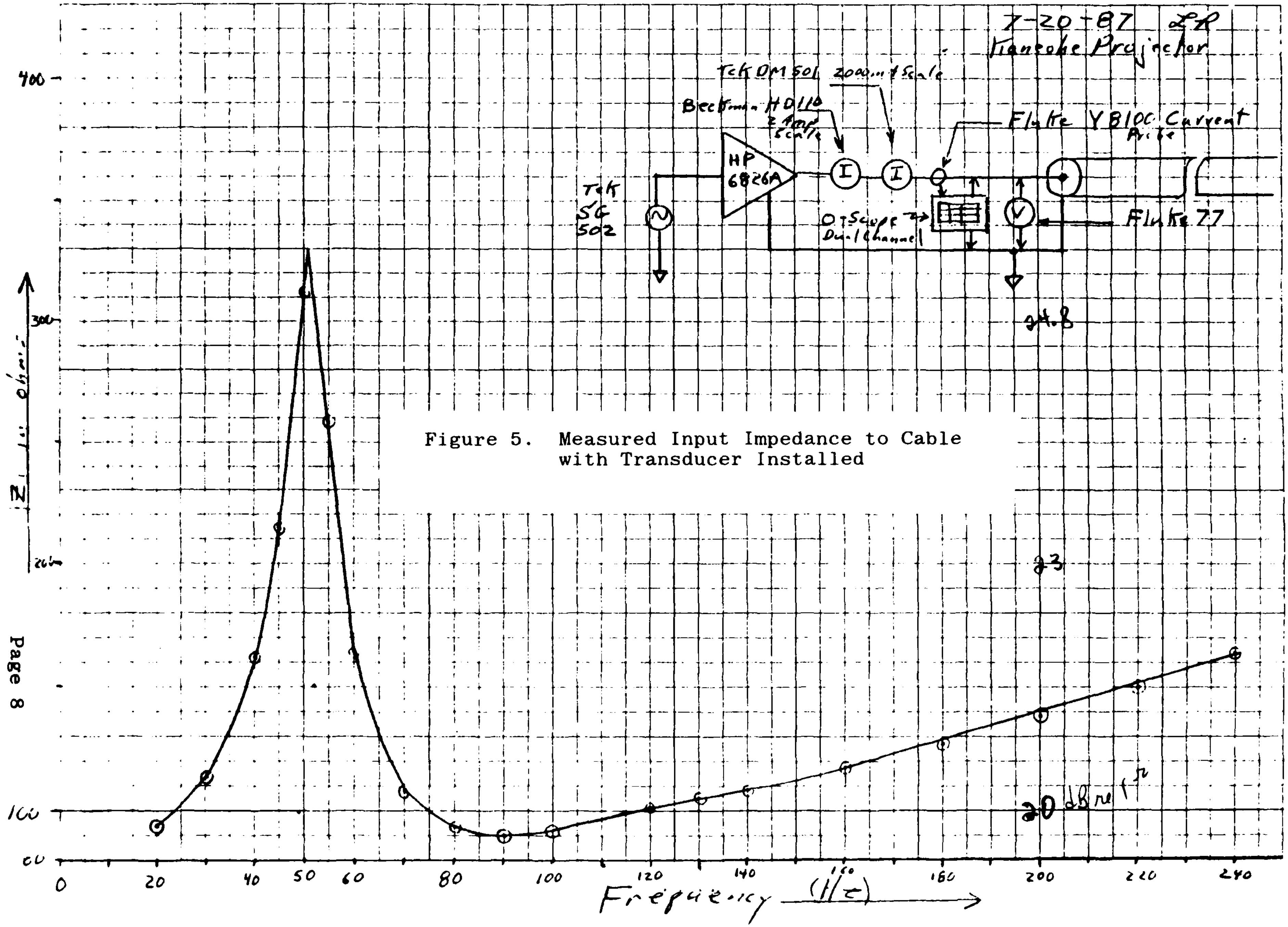
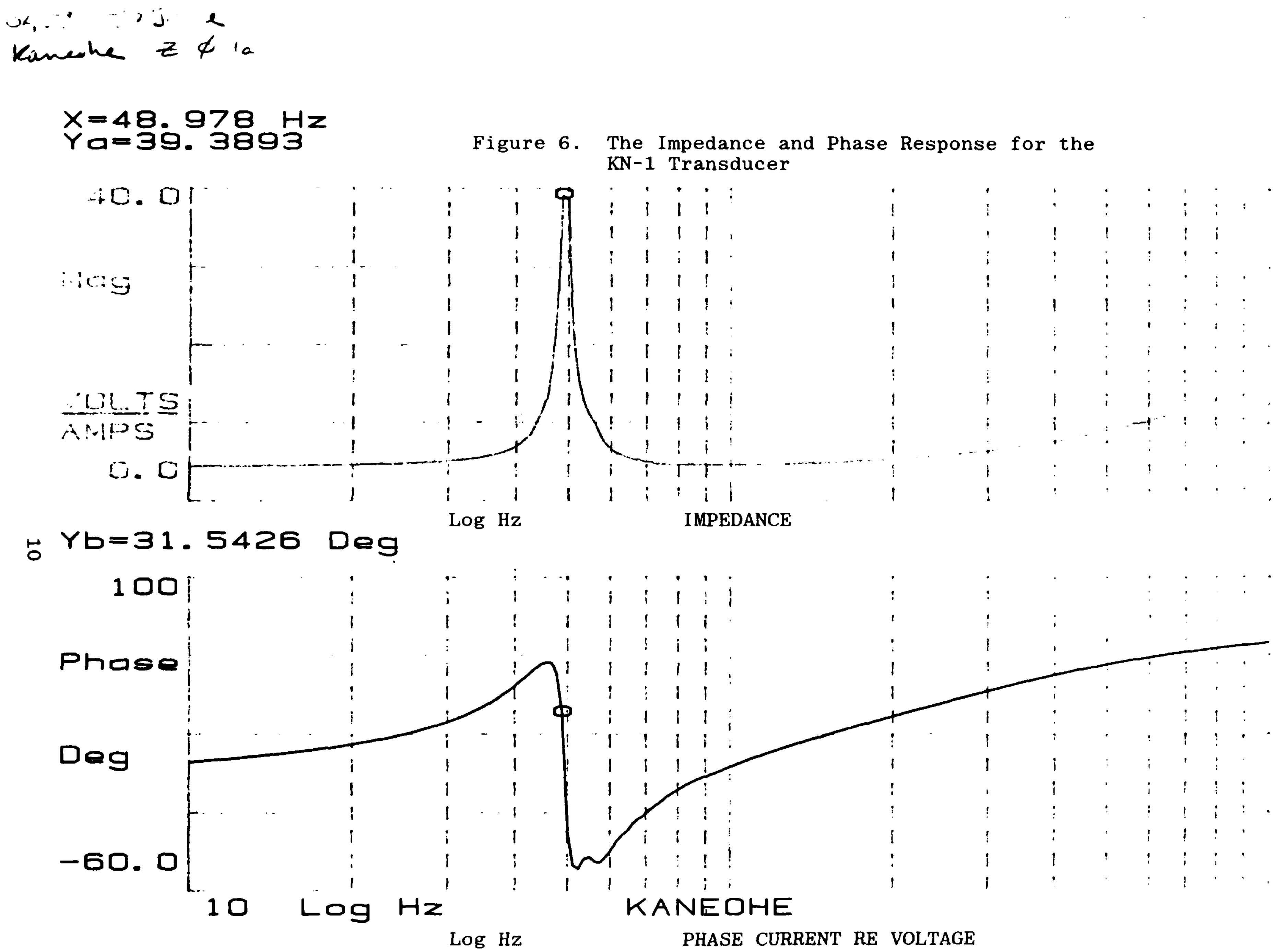


Figure 5. Measured Input Impedance to Cable with Transducer Installed

Table 1. Cable/Transducer Impedance Measurements vs Frequency

f Hertz	V_C Volts	I_C Amps	$\|Z\|$ Ohms
20	31.2	0.335	93
30	31.4	0.278	113
40	31.6	0.195	162
45	31.7	0.148	214
50	31.8	0.102	312
55	31.9	0.123	259
60	31.9	0.183	174
70	31.7	0.291	109
80	31.6	0.340	93
90	31.6	0.350	90
100	31.6	0.343	92
120	31.7	0.312	101
130	31.7	0.302	105
140	31.8	0.292	109
160	31.8	0.272	117
180	31.8	0.250	127
200	31.9	0.230	139
220	31.9	0.212	150
240	31.9	0.195	164

Figure 6. The Impedance and Phase Response for the KN-1 Transducer



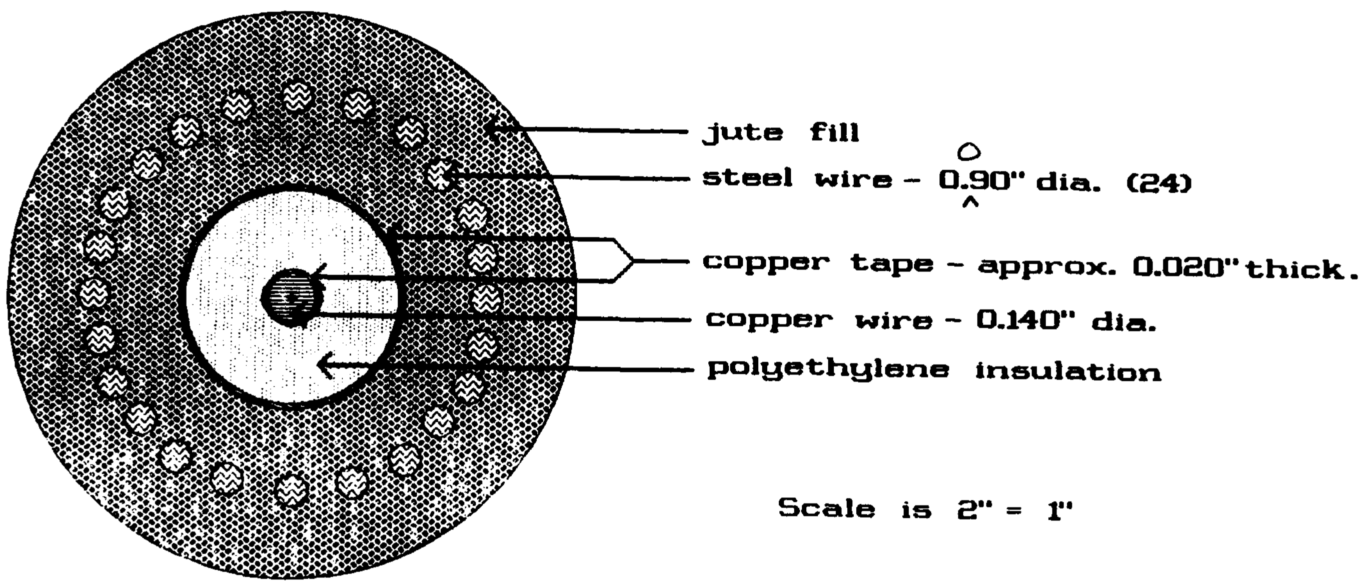


Figure 7. Physical Characteristics of Sea Cable

Table 2: Physical and Electrical Characteristics of Sea Cable

- Nominal Weight in Sea Water (Double Armor) = 5 lbs/linear foot
- Tensile Strength = 200,000 lbs/square inch
- Load Capacity = 31,000 lbs
- Electrical Properties
  - Center Conductor Size (Diameter) = 0.140 inches.
    Copper Wrap Adds 0.040 inches to Diameter.
    Effective Diameter = 0.180 inches.
  - Center Conductor Resistance
    - -- Equivalent Electrical Size = AWG 5
    - -- Resistance = Approximately 0.31 ohms/1000 feet
    - -- 29,000 Feet = Approximately 9.0 ohms
  - Return, Outer Shield
    - -- AWG 3 (Equivalent) = 0.04 square inches
    - -- Resistance = Approximately 0.12 ohms/1000 feet
    - -- 29,000 feet = Approximately 3.5 ohms
    - -- With Sea Water and Steel Shield = Approximately 3.5 ohms

4. SITE AND INSTALLATION DATA

Kaneohe Bay is located on the North Coast of the Island of Oahu, Hawaii. A tourist map is enclosed to aid in identifying the location (Figure 8). The dry-end electronics are located at the NOSC Hawaii Laboratory, which is co-located at the U.S. Marine Corps Air Station, Kaneohe Bay (shown in Figure 9).

The cable route from the NOSC Laboratory to the transducer site is shown on the chart of Figure 10. The actual site is approximately 4.5 miles from the Mokapu Peninsula.

Detailed cable run and bottom topography are shown in Figure 11, for the close region of the Mokapu. The charts in Figures 10 and 11 provide the necessary detail for transducer location. The final location of the transducer was established with a Mini-Ranger high-accuracy positioning system. These values have been translated into Lat-Lon as:

W 157.46.30
N 21.31

Some refinement may be made in the future, but only small changes in these coordinate values are expected. The primary location values for the recovery procedures will be with the Mini-Ranger, using a different grid system. A high-quality bottom topography chart is enclosed as Figure 12, and gives a clear picture of the local topography.

The installation configuration was developed to ensure that redundant recovery techniques would be available, and that minimal recovery and installation time would be required. These procedures and design constraints were considered important in supporting the annual recovery/installation/refurbishment activities required to keep the Kaneohe source operating properly on a continuous, long-term basis.

Figure 13 is a sketch of the installation, and indicates three recovery methods:

a) Primary : Float Line (1/2" Wire Rope)
b) Secondary: Grapple Line (1/2" Wire Rope)
c) Tertiary : Grapple for Double-Armored Sea Signal Cable

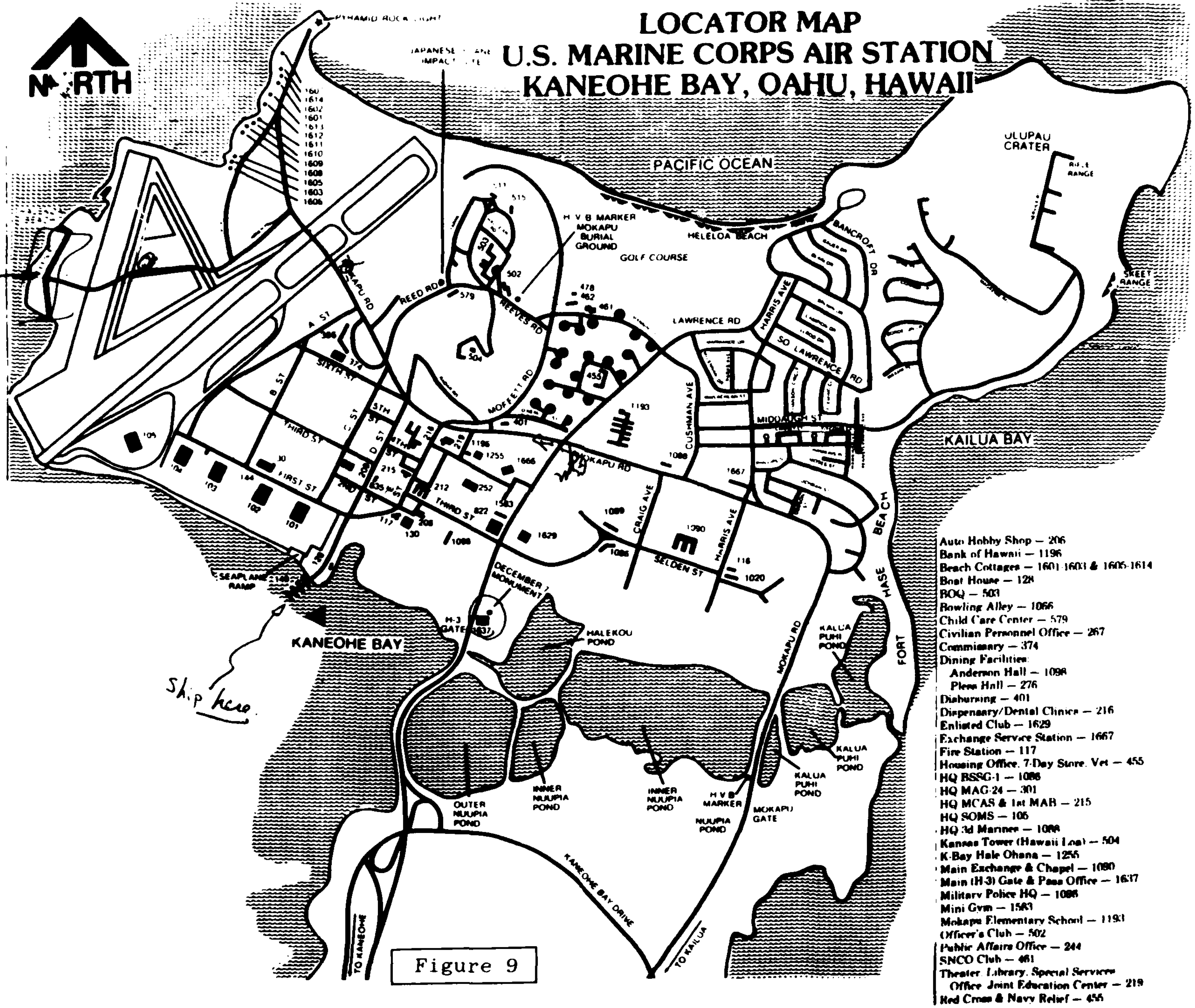
The transducer mounting frame is shown in Figure 14. The transducer bottom face is about 5 feet above the sea bottom when installed. The unit weighs about 3,000 lbs, not counting the attached sea cable, but with the transducer and transformer installed.

Appendix E includes a copy of the OP Plan that was followed in recovering the failed transducer, and installing the new KN-1 source.

A major contributor to the ease with which the HX-137 was recovered, and the KN-1 transducer was installed, was the SSP KAIMALINO and crew, managed by Harry Chalmers (NOSC Hawaii Laboratory). The platform was very stable in moderate swells, and the crew was well qualified and trained to do the job. With this type of support, the complete job was done in one day, with no delays or difficulties. Figure 15 is enclosed to show the properties of the KAIMALINO, and indicate some of the unique features that make it an excellent platform for handling heavy and delicate loads.


Distance from Waikiki
Turtle Bay Hilton
Kahuku
Hauula
Punaluu
Kahaluu
Waikane
KUALOA BEACH PARK
CHINAMAN'S HAT
Kaneohe
Waimea
Sunset Beach
Haleiwa
POLO FIELD
Pearl Harbor
Honolulu
Waikiki Beach
Nanakuli
Ewa
SANDY BEACH
MAKAPUU

Nose

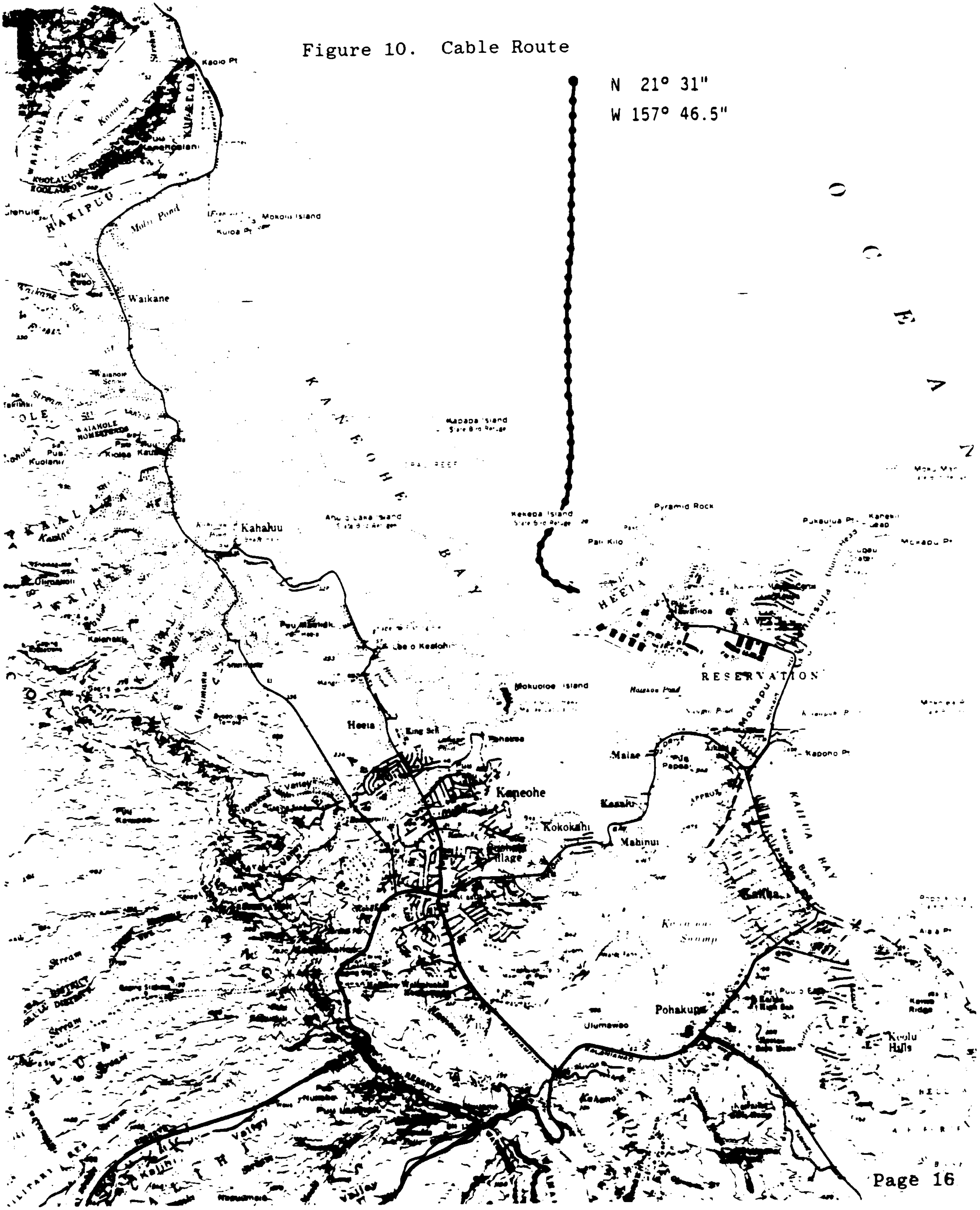


Auto Hobby Shop — 206
Bank of Hawaii — 1196
Beach Cottages — 1601-1603 & 1605-1614
Boat House — 128
BOQ — 503
Bowling Alley — 1066
Child Care Center — 579
Civilian Personnel Office — 267
Commissary — 374
Dining Facilities:
Anderson Hall — 1098
Pless Hall — 276
Disbursing — 401
Dispensary/Dental Clinics — 216
Enlisted Club — 1629
Exchange Service Station — 1667
Fire Station — 117
Housing Office, 7-Day Store, Vet — 455
HQ BSSG-1 — 1086
HQ MAG-24 — 301
HQ MCAS & 1st MAB — 215
HQ SOMS — 105
HQ 3d Marines — 1088
Kansas Tower (Hawaii Loa) — 504
K-Bay Hale Ohana — 1255
Main Exchange & Chapel — 1090
Main (H-3) Gate & Pass Office — 1637
Military Police HQ — 1086
Mini Gym — 1583
Mokapu Elementary School — 1193
Officer's Club — 502
Public Affairs Office — 244
SNCO Club — 461
Theater, Library, Special Services Office, Joint Education Center — 219
Red Cross & Navy Relief — 455

Ship here

Figure 9

Figure 10. Cable Route



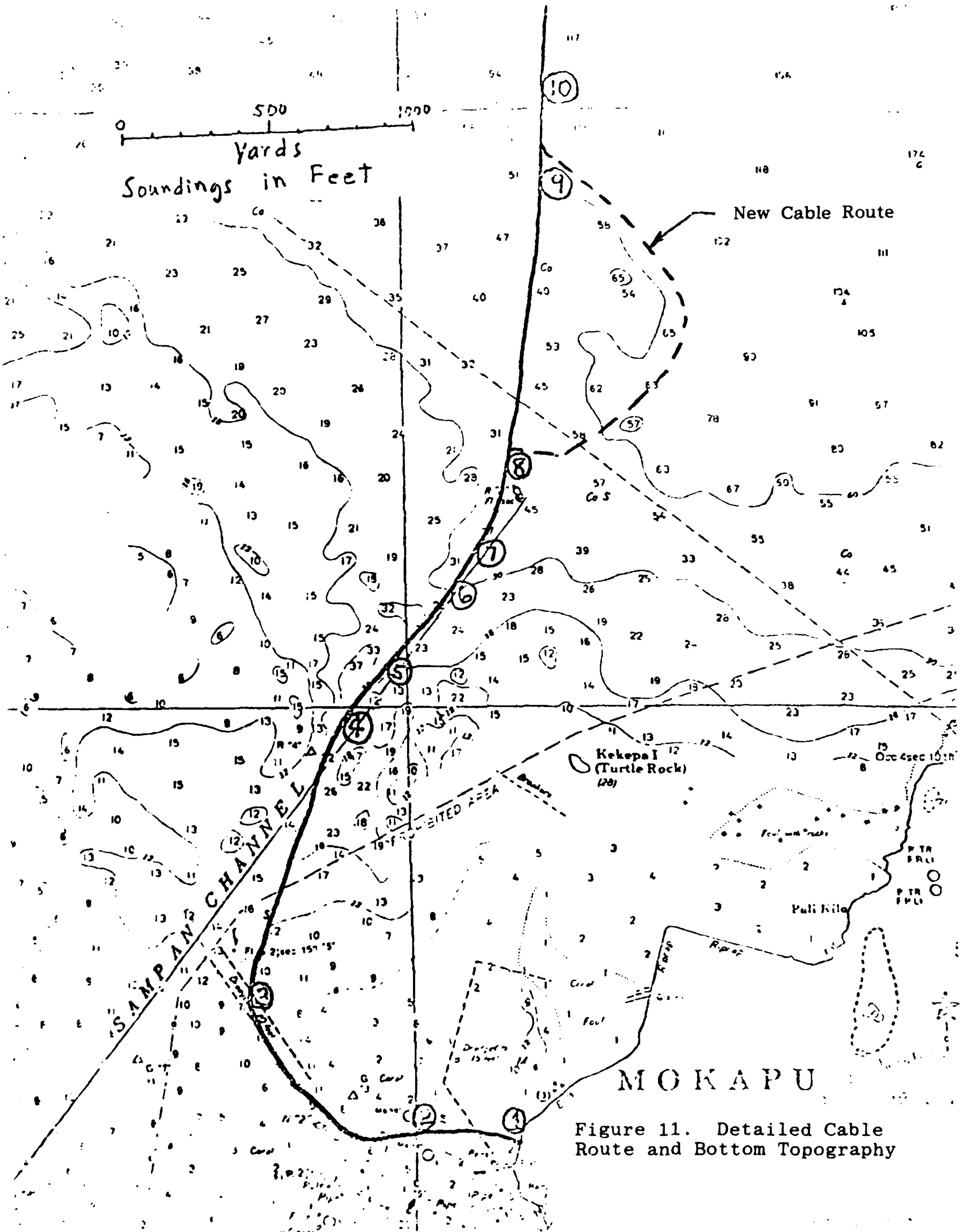
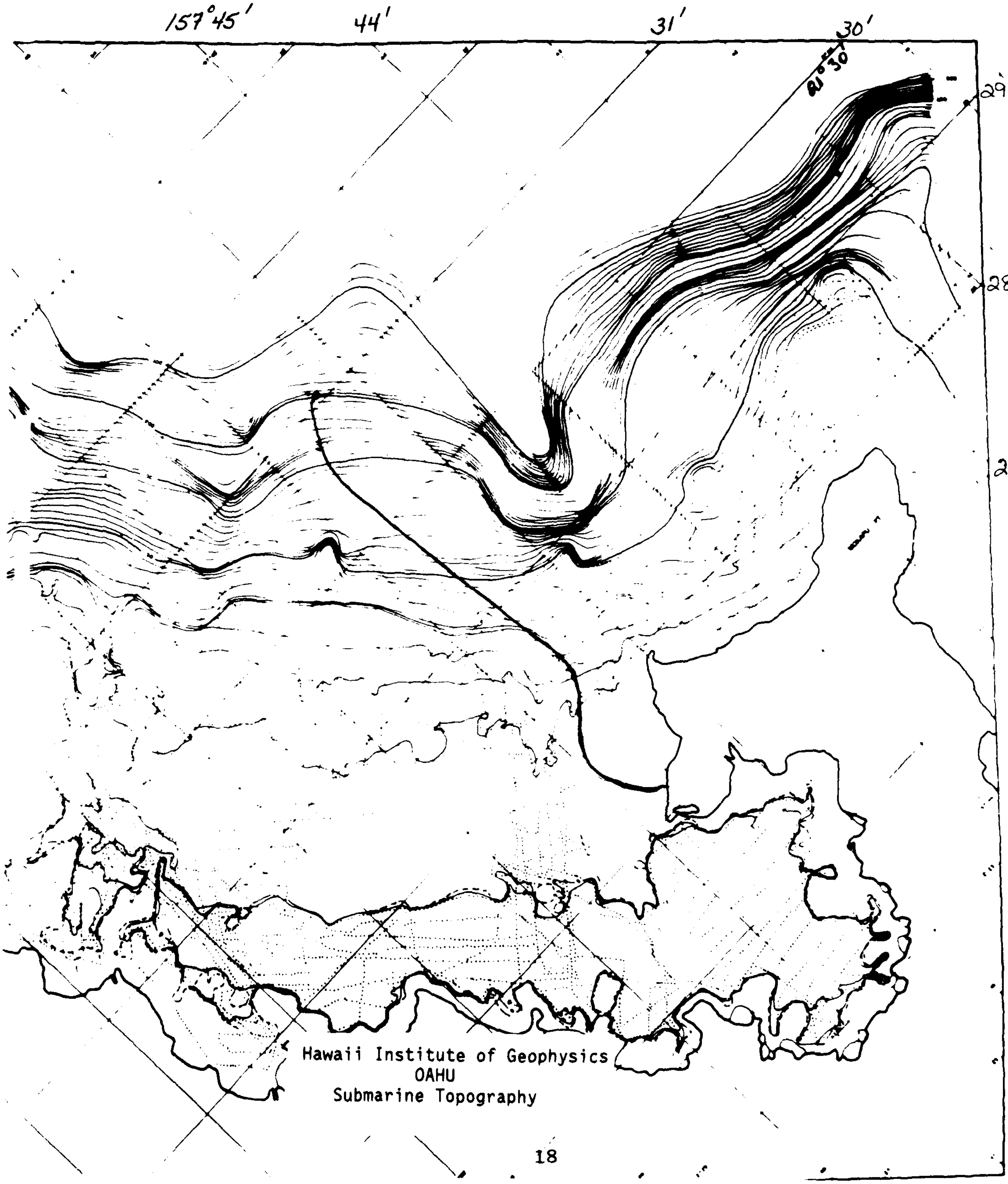


Figure 11. Detailed Cable Route and Bottom Topography

Figure 12. Bottom Topography Chart



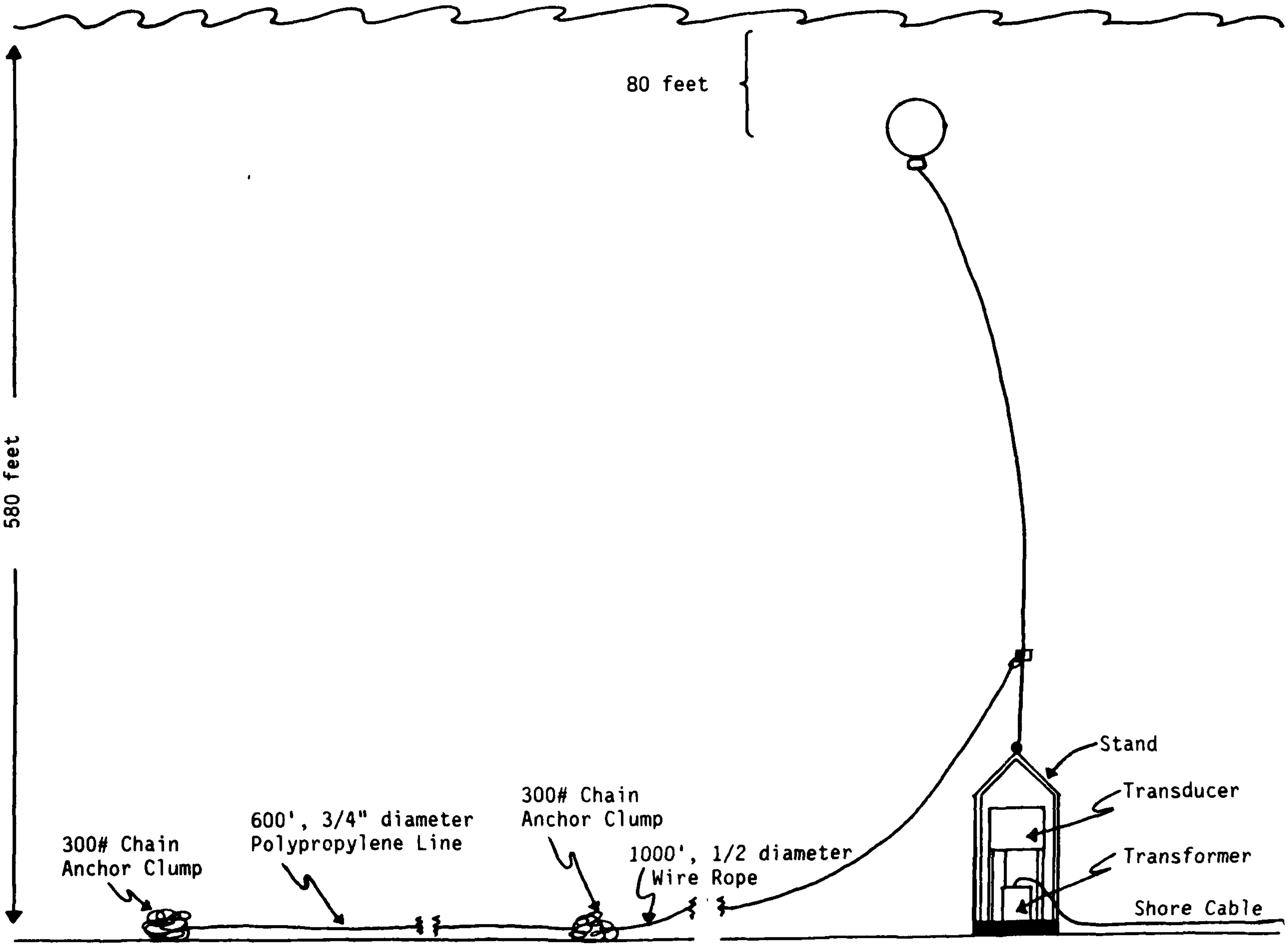


Figure 13. Simplified Kaneohe Installation

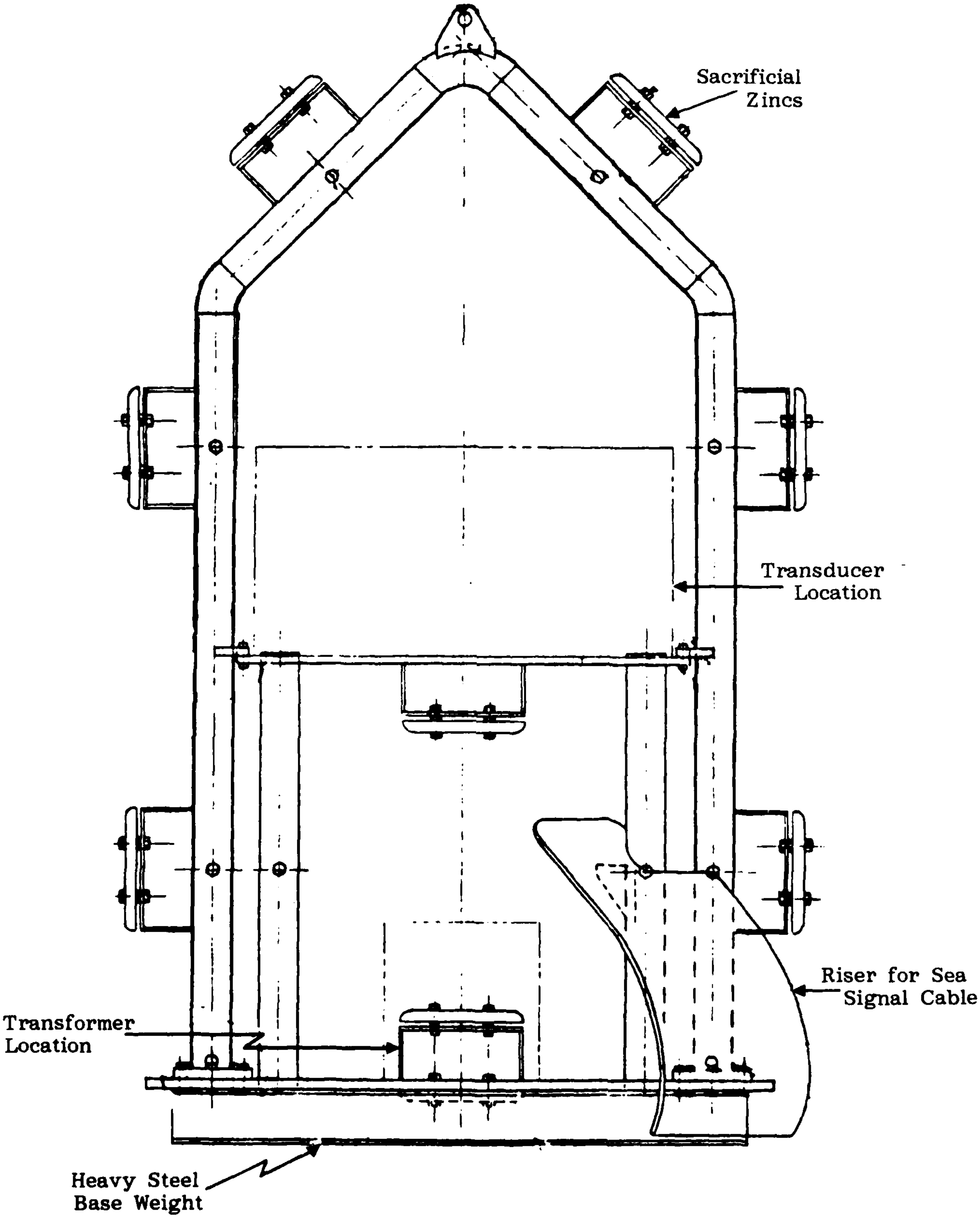
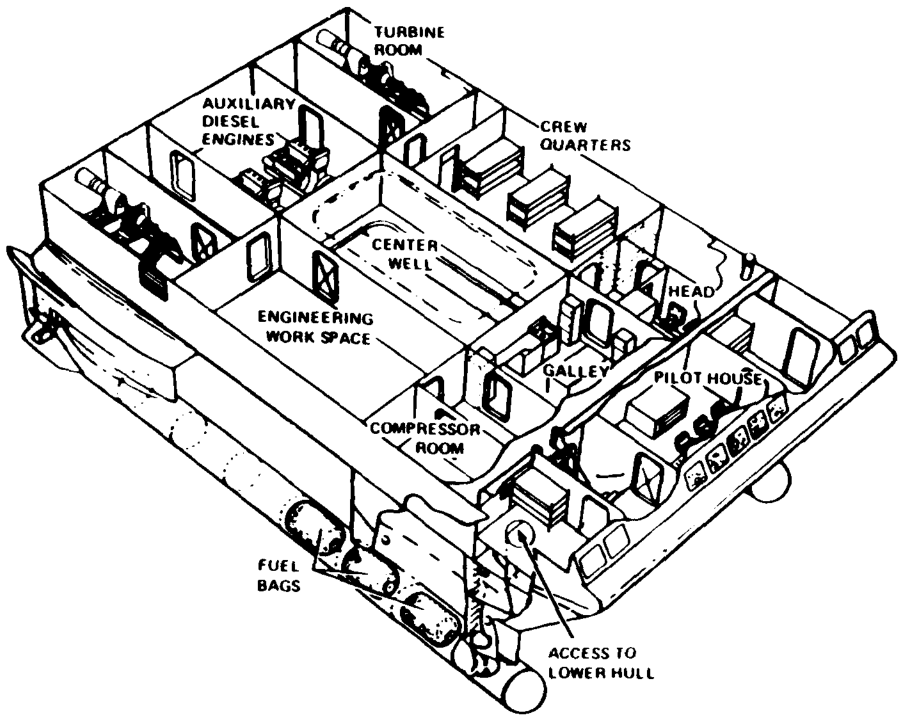
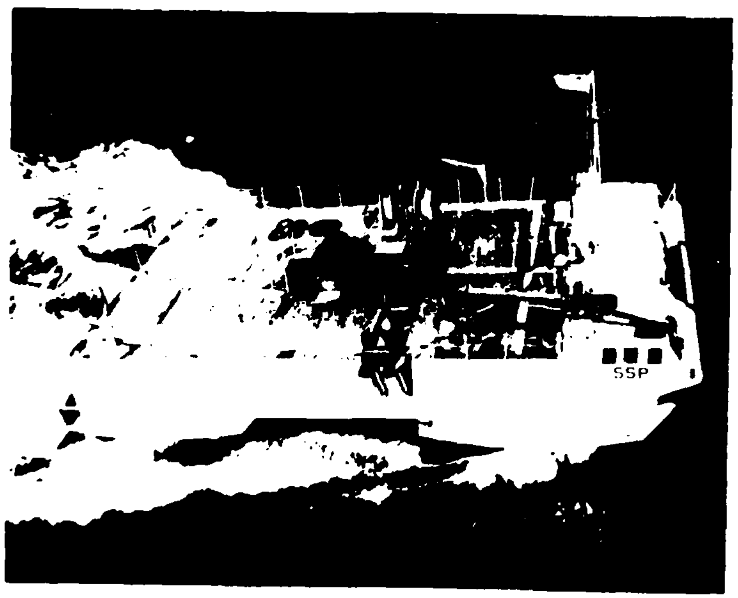


Figure 14. Transducer Mounting Stand





Kaimalino CHARACTERISTICS

Length Overall	88 Feet 4 Inches
Beam Overall	46 Feet 6 Inches
Well Dimensions	23 X 12.5 Feet
Draft (Normal):	15 Feet 3 Inches
Gross Payload	34.9 Long Tons
Mission Payload*	16 Long Tons
Main Propulsion	T64-GE-6B Turbines (2) 2204 HP Each
Auxiliary Propulsion	8V-71T Detroit Diesels (2)
Propeller System	Wilkinson Controllable Pitch, 4 Blade 6.5 Foot Diameter
Maximum Speed	24 Knots
Cruise Speed	15 - 18 Knots
Auxiliary Speed	0 - 6 Knots
Hydraulic Capacity*	60 GPM at 2,000 PSI
Electrical Capacity*	300 Kw, (480, 240, 120 VAC - 3 PH, 60 Hz)
Deck Area	3,400 Square Feet (with well covered)
Displacement	217 Long Tons
Berthing Capacity	10 Crew, 6 Scientists
Lower Hull Diameter	6.5 Feet

*Available for Customer Support Equipment

ANCILLARY EQUIPMENT

Sperry Doppler Speed Log (± 0.1 Knots Resolution)
Marconi Radar (0 - 36 Mile Ranges)
VHF, UHF, and HF Military and Civilian Frequencies
Depth Recording Fathometer (0-1250 Fathom Ranges)
Propeller Shaft Torque and Speed Indicators
Underwater Cameras and Observation Ports
Automatic Motion Control System (With Motion Outputs)
Mark-27 Gyrocompass
Wind Speed and Direction Indicators

Figure 15

5. LESSONS LEARNED

After the initial new transducer installation, a significant change in electrical properties looking down the cable was noted after 12 hours of operation. The new installation was recovered and returned to shore for evaluation. Analysis indicated that the problem was not with the transducer, but with a failed matching transformer. A new transformer was built and installed, and the source was re-installed and checked-out. The system is now operating properly.

From this effort, two "lesssons learned" issues were noted:

1. The transformer had developed a short in the primary winding, due to the use of square wire that was of too large a dimension; the solution was to use wire of a smaller dimension, which was wound on the transformer core without incident.

2. In a second issue, it was noted that the transducer housing had mud on the top section. This indicated that the transducer had been tipped on its side during the first installation; a solution developed by the NOSC installation manager was to lift the transducer by its float pendant after all installations were complete to ensure that it was hanging vertically and would sit upright.

6. SUMMARY

The KN-1 source has been installed and works properly (after a transformer change was made), and the signal has been detected at a receiver approximately 4,000 km from the site. Some changes will be made in the follow-on transducer design, primarily in the external package and the platform, in order to improve handling during installation.

As stated earlier, many people contributed to the success of building a new transducer in 90 days -- an almost impossible task. Availability of key materials, strong support from ONR contracts to expedite necessary contracting actions, and the many hours of late-night work were essential. The cooperation of ONR and SPAWAR to meet the objectives was a basic ingredient in getting the job done.

APPENDICES

A: Status Report: Kaneohe Acoustic Projector

B: Memorandum: Engineering Analysis to Evaluate Alternative Kaneohe Sources

C: Management Plan for Replacement of Kaneohe Source

D: Key Participants in the Kaneohe Source Replacement

E: Operation Plan -- Kaneohe Projector Refurbishment

APPENDIX A

STATUS REPORT

KANEOHE ACOUSTIC PROJECTOR REPLACEMENT AND REPAIR

14 December 1986

James D. Pugh

BACKGROUND

In August 1978, the Institute for Acoustical Research (IAR), under Office of Naval Research sponsorship, and with NOSC assistance, installed an HX-137 acoustic projector off Kaneohe Bay, Hawaii. A cable was laid from the projector to the control electronics located in the Missile Impact Locating System (MILS) Room of Building 1181 at NOSC Kaneohe. The sound source was used by the Acoustic Research Center (ARC) for long-term, long-range investigations into the influence of mesoscale environmental processes on acoustic propagation. The ARC maintained adminstrative and physical control over the Kaneohe Acoustic Projector System.

The HX-137-D projector was placed at 21-31N, 157-46½W on the ocean floor in 600 feet of water. It is 36 inches high, 28 inches in diameter, and weighs 1,800 pounds in the air. With its stand, it weight 5,500 pounds in theair. The SB-coaxial cable that originally connected the HX-137 to the shore electronics was about 27,000 feet long. The first 1,000 to 2,000 feet of cable from the projector is double-armored to provide sufficient strength to lower and raise the projector to and from the ocean floor. The rest of the cable is single-armored.

The resonant frequency for the HX-137 is 133 Hz. At that frequency, with a 3,200-volt maximum potential across the transducer ceramics, it will produce a source level of 200 dB re a micro-pascal; 173 dB at 50 Hz. According to a representative of the projector's manufacturer, there is a wire fuse connected electrically in series between the transducer staves and the cable junction box. A handwritten, unsigned note in the projector operating manual mentions an on-board one-amp fuse in series with the whole transducer.

In August 1980, the original HX-137 was replaced with another. The serial number on the original unit was 002; on the replacement, 003. The replacement was accomplished by cutting the SB-coaxial cable just seaward of the barrier reef in about 100 feet of water, reeling in the two miles of cable to the projector, and then lifting up the projector by the SB-coaxial cable. The replacement projector was lowered to the bottom, and the cable relaid and spliced. Once the original projector was out of the water, it was noted that the stainless steel nuts and bolts used to tighted the bands that hold the rubber boot in place were missing. A diver inspection of the near-shore portion of the cable was conducted in September 1983. Some cable abrasion was observed in a 500-yard section of cable in an are where it is subject to surge caused by open ocean swell starting to shoal. At that time, Roger Buecher of the NOSC Kaneohe Laboratory recommended the stabilization of the cable in the abraded area by placing bags of dry concrete along the cable at 5- to 10-yard intervals. The recommendation was not heeded. In March 1984, a cable short developed in the abraded area. A diver inspection indicated that section of cable was no longer serviceable.

In April 1986, the cable was cut beyond the abraded portion. Electrical tests were conducted to demonstrate that the cable seaward of the cut functioned properly, and that the projector was in proper working order. Diver inspection indicated that the cable

inshore from the abraded portion was intact. At that time plans were made to replace the abraded portion of the cable so that Commander Ocean Systems Pacific (COSP) and an ONR project could use the projector. COSP provided $11K to conduct the cable survey and electrical tests.

In September 1986, 6,560 feet of SB-coaxial cable was spliced into the cable to replace the abraded portion. With help from PMW 143-60, a 7,000-foot length of SB-coaxial cable was obtained at no cost from a cable-laying ship that was in port at Honolulu. The replacement cable was placed in a more benign path, and stabilized with concrete bags. The cable length from the projector to the shore terminus is now about 29,000 feet. Electrical tests designed to demonstrate the integrity of the cable and transducer were conducted. The tests revealed an integral cable with a viable transducer on the wet end. COSP provided $40K to fund this task.

To prepare for the availability of the projector after the cable repair, the power amplifier that drives it was refurbished, and a new matching network was designed and installed. This new dry-end setup is designed to deliver a maximum 1100 volts, one-third the maximum allowable voltage for the HX-137. The original ARC installation at NOSC Kaneohe included a computer with stored waveforms. A modem was connected to the computer. This arrangement provided remote access to, and control of, the dry-end electronics. No attempt has been made to refurbish this computer.

On 23 and 24 September 1986, test signals were fed to the projector at 56 Hz, 133 Hz, and 158 Hz. Both high and low voltages were applied to the HX-137 at these frequencies. The estimated maximum source level of 190 dB was produced at 133 Hz; 181 dB at 158 Hz; and 166 dB at 56 Hz; and 112 Hz was tested only at the low voltage of 124. Projector source level was detected easily by the ARC/SDL on sensors that are distant from the projector site. The 56-Hz signal at 166 dB was detected also, but barely. Greater processing gain was needed to detect this signal. At the conclusion of these tests, a 183-dB pseudo-random signal with 20-Hz bandwidth centered at 133 Hz was applied to the projector. Designed for use by the Ocean Tomography Experiment, this signal was to be left on indefinitely.

CURRENT ACTIVITIES

On 27 October 1986, the Ocean Tomography Experiment requested the source level be increased to 188 dB; it was.

On 4 November 1986, the ARC/SDL was notified that the projector was not functioning. The Ocean Tomography Experiment had not detected the HX-137 since it was first tested on 23 and 24 September. This explains the request for an increased source level. Only after the Ocean Tomography Experiment did not detect the Kaneohe projector once the source level had been increased, was it learned that the projector had not been functional since 23 and 24 September. Electrical tests demonstrated that the cable was intact, but there was no evidence of a transducer on the wet end. That is, the circuit was open where the transducer should be. The problem could be as simple as a failed on-board fuse. Considering the transducer has been on the ocean bottom for six years, it is more realistic to speculate that its mechanical condition has deteriorated to the point where a catastrophic failure has occurred, which, in turn, caused the fuse failure. The first HX-137 was in place only two years before corroded stainless steel nuts and bolts caused its failure. Estimates to repair the HX-137 range from 3 to 6 months, at a cost of $50K to $100K.

Since 4 November 1986, the ARC/SDL has been trying to locate a replacement transducer and submersible devices to aid in recovery of the HX-137, and installation of its replacement. Transducers that produce high source levels at low frequencies are difficult to find. But, two HX-231 transducers were located at Bay St. Louis. They were originally purchased by the Long Range Acoustic Propagation Project (LRAPP), and are currently in the custody of the ASW Environmental Acoustic Support (AEAS) Program. The HX-231 is superior to the HX-137 in that it resonates at a lower frequency (110 Hz), and will provide a source level 10 dB higher than the HX-137 at the frequency of interest by COSP. Driven at 1100 volts, HX-137 performance is marginal at COSP's frequency of interest. At one point, the AEAS Program had agreed to lend the ARC/SDL one of the two HX-231 transducers for use at Kaneohe.* A very tight schedule was devised, and would have had the HX-231 in the water by 19 January 1987. This plan fell through when AEAS withdrew its offer. To date, the ARC/SDL has no replacement for the defunct HX-137.

The Kaimalino Cost Center at NOSC Kaneohe has made preliminary arrangement with the University of Hawaii to use the manned submersible Makalii during recovery of the HX-137 to be hoisted aboard the Kaimalino without the necessity of cutting and resplicing the cable. An estimate of $33K was submitted by the Kaimalino Cost Center to retrieve the HX-137, and install a replacement. This estimate covers the cost of the Kaimalino and the Makalii. Another $8K was requested to apply more concrete bags to the newly spliced portion of the cable. Some of the concrete bags applied to the new cable section did not set, and eventually washed away. Initially, NOSC San Diego estimated that $13K would be required to inspect and prepare the HX-231 for installation. This estimate included the cost of a new platform on which to place the transducer. The platform on which the defunct HX-137 sits would have been inadequate for the HX-231.

The total cost estimate to retrieve the defunct HX-137, and install a replacement transducer such as the HX-231, totals $54K. To this amount must be added the cost to repair the HX-137, an estimated $75K, and another $33K to retrieve the replacement transducer, and install the refurbished HX-137. All together, the estimated cost is $162K to return the HX-137 to service, and provide projector services while it is being refurbished.

Should no replacement transducer be found, the estimated cost to return a refurbished HX-137 to service would be $147K; a $15K savings associated with cutting two days from the Kaimalino and Makalii schedules; one day saved by not having to put down a replacement transducer, and one more associated with not having to retrieve the replacement when the refurbished HX-137 is reinstalled. Only $15K is saved by not providing projector while the HX-137 is being refurbished.

If the ARC/SDL is to provide projector services in the future, it would be prudent to acquire two transducers; one to be held in reserve to replace the in-service unit whenever it fails. The ARC/SDL will need to budget for the operation from time to time. In fact, it would seem wise to swap the transducers on a biennial or triennial schedule, to avoid the problems associated with anticipated transducer failures. The estimated cost for this option in FY-87 is $54K; no HX-137 refurbishment cost, and no reinstallation cost would be incurred. If the ARC/SDL were required to refurbish the HX-137, then the estimated cost would be $129K in FY-87.

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*This statement is incorrect. The AEAS office was not consulted regarding the HX-231 transducer.

COSP is most interested in having the Kaneohe projector operational again. Because the ARC/SDL is trying to support COSP, I called Captain Logan, Chief Staff Officer, for COSP on 9 December 1986, to inform him of the status of our efforts to get the projector "on the air" again. At that time, I asked if he could make inquiries about who in the Navy might establish the priorities for the use of Navy-owned equipment such as acoustic transducers. It is my understanding that COSP plans to talk directly with AEAS Program personnel concerning the use of their HX-231 transducers. If a higher priority can be established for ARC/SDL use of the HX-231's than can be established by AEAS, then perhaps those units should be transferred to the ARC/SDL. Alternatively, the Kaneohe acoustic projector operation might be assigned to AEAS. Until the question of replacement transducers is resolved, firm schedules, ship commitments, and cost estimates cannot be finalized.

The search for a replacement transducer and required funding continues.

APPENDIX B

15 March 1987

MEMORANDUM

ENGINEERING ANALYSIS TO EVALUATE AND SELECT AN ALTERNATIVE KANEOHE SOURCE

J.L. Collins

1. INTRODUCTION

The fundamental problem is the failure of the Kaneohe acoustic projector, and the desire to replace the unit with a long-life source that generates slightly higher output over a somewhat broader operating bandwidth. The details are contained in Appendix A.

The purpose of this memorandum is to outline an alternative approach to meeting the performance objectives suggested by Pugh, Spiesburger and Jacob, and outline a plan for solving the issue.

2. PERFORMANCE REQUIREMENTS

Measurements to be made require a source with a relatively wide, high level output. Some measurements will require more or less continuous acoustic signal projection. The basic requirements are:

- Operating Depth - 200 m
- In the 110-150 Hz Band:
  - Source Level : 185 dB re Pa/Hz
  - Transmitting Bandwidth: 20 Hz
  - Three to five (3-5) Days On; Two (2) Days Off
- In the 50-65 Hz Band:
  - Source Level: 180-185 dB re Pa/Hz
  - Tonals : Very Low Harmonics
  - Limited Transmitting Times

3. HX-137 PROJECTOR

The failed acoustic projector was installed at the site in 600 feet of water. Its physical dimensions are 28 inches diameter, 36 inches high, and 1,800 lbs in air; the unit operates at the end of a 29,000-foot cable. The acoustic properties are: maximum output at resonance of 133 Hz gave 190 to 200 dB; 158 Hz gave 181 dB; 56 Hz gave 166 dB. The unit was re-activated in late September 1986, and failed about 30 days later; repair estimates are in the Pugh memo. Note that the source level of the HX-137 was considered inadequate at some frequencies. Also note the unit was in the water for a total time of 6 years, but cable problems had prevented its use for years. Estimates are that approximately 6 months and $145K are required to refurbish the HX-137 projector.

4. HX-231 PROJECTOR

In the late 60's and early 70's, Honeywell built a total of four (4) HX-231 or equivalent projectors (two units consisted of two or three projectors operating in parallel, strapped together). Two units (the multiple projectors) were delivered to NADC; the two single units were delivered for LRAPP/NUSC/NOSC use. Some units were tested and updated in 1971 and 1983; Honeywell has no other information as to their disposition. However, both multiple projectors have been lost at sea at different locations. The two single units are currently being used by AEAS, and are committed to at-sea experiments for the indefinite future.

Properties of the HX-231 are as follows:

- 25" diameter by 36" long
- Bandwidth: 50 to 300 Hz
- Source Level: 195 dB at 110 Hz Resonance
  183 dB at 50 Hz
  200 dB maximum source level at resonance
  <u>and</u> maximum drive
- 1100 Volts maximum drive
- 14 Staves per Transducer
- Weight: 2300 lbs in air

The HX-231 is a ceramic bender-bar projector, and therefore should enjoy reasonable life expectancy if drive levels are kept at less than peak values; also note that the resonant frequency is at 110 Hz, lower than the HX-137, but still above the low frequency of interest.

Based upon the performance levels desired, the HX-231 should be closely evaluated as to its ability to meet the long term acoustic source levels required over the frequency bands indicated. Further, the age of the transducer should be considered, and refurbishment should be seriously considered, if not a major re-work.

The use of the HX-231 with the long cable at the site requires that the power driver and signal cable (0.9 fd and 29 ohms dc) must also be re-evaluated in terms of the difference in the load the HX-231 will present. The need for a new transformer at the projector, some circuit protection methods, etc., should be evaluated in terms of system performance and life.

5. ALTERNATIVES

It seems that refurbishing the HX-137 is costly, time consuming, and probably inappropriate since it is very marginal or inadequate in meeting the required source level and operating frequencies.

The HX-231, in addition to being heavily committed, is a very expensive transducer which is modestly adequate to meet the acoustic performance required; as indicated earlier, system age must be fully considered in any permanent installation consideration. As with any device of this type, it can be driven harder (limited by voltage breakdown levels) but life expectancy will decrease with higher drive levels. Estimated delivery of a new unit for replacement is 12 months, and cost is estimated to be in the \$200K to \$250K range.

The objective to meet more or less continuous, steady-state operation at some frequencies presents unusual problems, primarily because of the low frequencies and high source levels required (which implies large displacements of the driver). A more effective approach may be to use a lower cost projector (say on the order of 60% to 70% of the cost of the HX-231), but with a shorter operating window before refurbishment is required; the alternative being presented is a moving coil projector. The concept and rationale are outlined below:

Cost	:	2 Moving Coil Units \$280K
Delivery	:	1st Unit in 90 Days; 2nd Unit 30 Days Later
Size	:	24" Diameter by 30" Long
Weight	:	1200 lbs in Air
Bandwidth	:	$\pm$2 dB - 50-300 Hz
Source Level	:	190 dB Minimum across Band 200 dB at 50 Hz Resonance
Power Input	:	Approximately 4 to 6 Kw, Total

An operating life approaching 12 months may be practical. Steady-state, long-term experience with J-9, J-11 or J-13 moving coil projectors (NRL/Orlando) is non-existent; these units, which are the nearest equivalents, last for many years, but are operated for comparatively short continuous time periods. In discussions with NRL/Orlando moving coil experts, their concerns were:

- Temperature rise due to the large electrical drive dissipation (efficiency approximately -20 dB: 59 acoustic watts requires about 5 Kw electrical)
- Suspension failure over long time, continuous operation
- Salt-water corrosion of metal and rubber components, and associated fatigue/failure

Discussions were held with Mr. Bernie Willard, who has extensive experience with moving coil transducers. The issues of temperature, suspension failure, and salt-water corrosion were discussed.

- Temperature rise due to electrical power dissipation in the moving coil is a factor that must always be a design consideration. The coil is in very close proximity to the magnet, which is very massive and is in direct contact with the case which is immersed in the ocean's thermal sink. The volume between the coil and the magnet is also filled with a special, thermal conducting fluid. This will limit the temperature rise to manageable values since the heat load can be readily transmitted into the seawater.

- The only suspension is the rubber seal that supports the 12" piston. Since the transducer is mounted vertically, lateral suspensions will not be required. The seals are approximately 2" wide, and at 50 Hz and 190 dB source level, a piston excursion of only 0.050" RMS (0.150" P to P) is required. A special synthetic rubber will be used to minimize both temperature and salt-water effects.

- Active metal components (such as the piston face) will be Inconel, but special stainless steel material will be used for the case. Typical life expectancy should be well beyond 12 months. Electrical connection poses no unusual problems.

The NRL/Orlando engineers made a test suggestion, an excellent suggestion, which is to operate the projector at a steady-state, nominal power level for one week in the ocean. They suggested that if it operates over this time period without problems, it will probably operate for an extended time period, possibly 12 months, depending on material failures. One other suggestion was to disassemble the projector after the short time test, examine the components for deterioration due to thermal effects, and determine a fix, if required.

An ocean engineering effort should also be carried out to design the transducer/mount/cable system for maximum ease of installation and recovery. It is likely that acoustic releases, sub-surface floats, etc. could reduce recovery costs while mount/cable interface design may help reduce installation time and cost. The objective is to plan on a routine refurbishment of a far less expensive transducer, supported by a less expensive installation and recovery process, while meeting or exceeding the acoustic source requirements.

6. THE DEVELOPMENT AND INSTALLATION PLAN (See Figure 1 for Time Line)

A. Commence work on the design and construction of the first moving coil transducer.

B. Survey the site, obtain bottom topography charts, and review operational history at the site. Review power amplifier capabilities; evaluate existing cable.

C. Start ocean egineering design of mounts, cable interface, installation and recovery procedures. Provide guidance to moving coil transducer builder regarding mount and cable interface design; arrange for recovery of disabled HX-137 and mounts if necessary.

D. Task contractor to develop necessary hardware and procedures for transducer mount, cable interface and anchor system; develop design and start construction of power amplifier.

E. Review transducer design; evaluate test plans. Review ocean engineering designs with particular concern of transducer installation and recovery techniques; review power amplifier design and construction.

F. Complete installation mounts, junction boxes and installation and ocean engineering.

G. Install bottom mounts, anchors, J-boxes and transducer tracks.

H. Install transducer, mate leads through J-box, check transducers for performance and leaks.

I. Do cal checks; secure framework; deliver documentation.

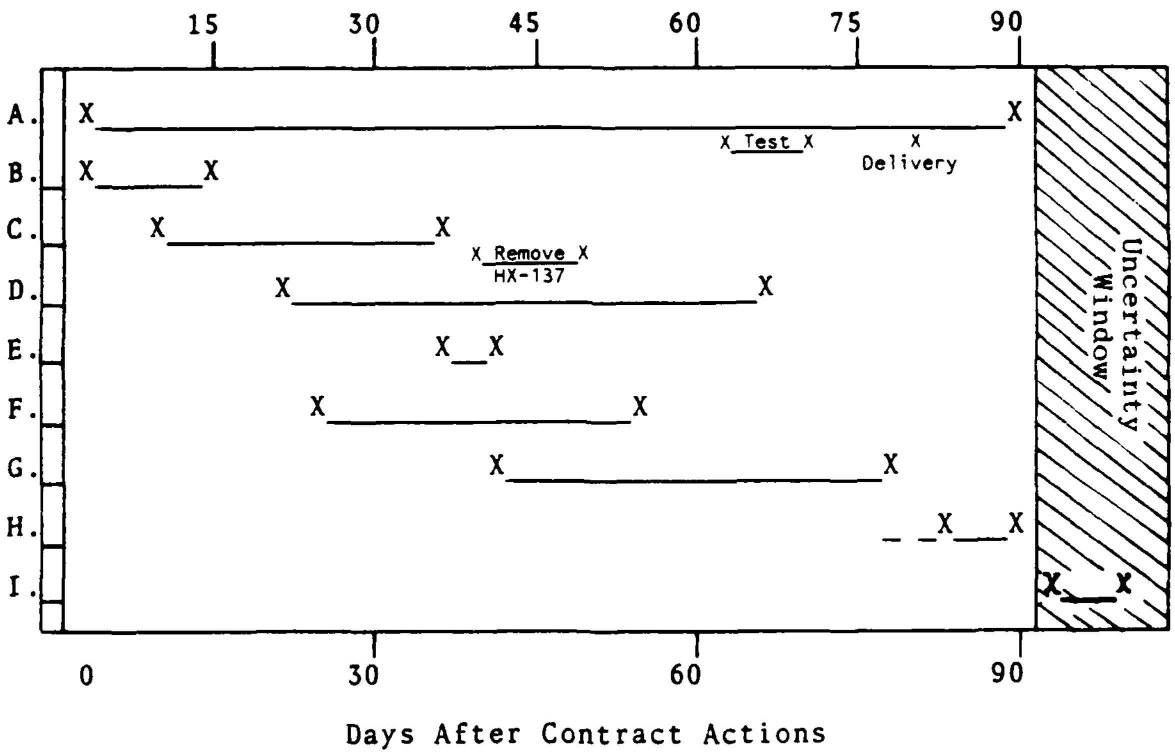


Figure 1

7. CONCLUSIONS

The net results indicate the moving coil transducer should meet the acoustic and operational objectives, on a cost/performance basis, when cost, time, risk, acoustics performance, and installation/handling issues are considered.

- HX-137 is not a viable source

- HX-231 is not a good choice because of: sea test commitments; age (it will require considerable refurbishment/overhaul before reliable use is possible); power driver, transformer and cable matching issues; it will require extensive time and funding to be made usable on a permanent or semi-permanent basis; purchase of a new HX-231 will require 12 months for delivery and approximately $200K; and acoustic projector properties are marginal, especially when drive level/reliability are considered.

  A new bottom mount will be required for the HX-231, along with installation and recovery system engineering procedures, even for short time operation.

- Moving coil seems viable. The new, moving coil design should cost about 60% to 70% of a new HX-231. Cost will be similar to the expected HX-231 refurbishment cost (not verified, only estimated).

  Proper ocean engineering early in the new design should reduce installation and recovery time and costs from those experienced with the HX-137 and expected with the HX-231.

  Two moving coil transducers would be built at a cost of approximately $280K (one unit in FY-87, a second in FY-88). This will give a backup as well as provide for routine maintenance and replacement every 12 months or so.

  Installation and recovery procedures can be expedited with RPV-Video and small boats (50 feet) to reduce cost since the air weight/water weight of the moving coil (1200 lbs in air) is considerably less than the HX units.

  The acoustic properties are satisfactory, but the power driver will require replacement. Long-term life of the moving coil transducer (about 12 months) is not proven, and is the key risk; design to this goal will be employed.

  Engineering, foundation and installation/recovery cost will be very similar for either the HX-231 or moving coil projectors.

  All of this implies a wet-end solution only, and does not address long-term operation and maintenance of the dry-end system. A system manager must be designated to maintain and operate the system for overall efficiency to be achieved.

APPENDIX C
30 March 1987

Management Plan for Replacement of Kaneohe Source

Background

The Kaneohe source failed in October 1986. Two replacement alternatives to utilize either the failed HX-137 (refurbish) or an HX-231 projector have been evaluated. Either projector would require extensive refurbishment and a new ocean-floor foundation would be required for the HX-231; in addition, the HX-137 is marginal in meeting required acoustic performance. Approximately 6 months would be required to complete the refurbishment.

Recommendations

A third alternative is to provide a new source. An analysis was conducted in which both bender-bar and moving coil transducers were evaluated. Cost, performance, delivery time, installation issues, etc. were evaluated, primarily for the HX-231 and moving coil transducer. This analysis was presented to SPAWAR Command (PMW-180) on 27 March 1987. This analysis indicates that the moving coil transducer is preferred but that routine annual maintenance and refurbishment should be planned; also note that some risk was identified since the effects of long-term, continuous use of moving coil transducers is not fully known.

Implementation Plan

Several major tasks must be completed and the system integrated in order to deliver the operational source within the time frame desired. These tasks are as follows:

1. Transducer Development

Argotec, Inc. (Ft. Lauderdale, FL), will be funded to build, test, calibrate and deliver a moving coil transducer on or before 25 May 1987 to commence integration with the foundation and electrical components. The plan includes:

- Assemble transducer and base (25-31 May 1987)
- Conduct a 7-day maximum-drive test at operating depth (1-7 June 1987)
- Disassemble transducer, inspect, correct any noted deficiencies and re-assemble (8-13 June 1987)
- Conduct transducer calibration at NRL Leesburg facility (15-17 June 1987)
- Ship complete package to the Kaneohe site by MAC air flight (18-21 June 1987)

2. Foundation

An award will be made to an ocean engineering company to: 1) provide guidance to the transducer manufacturer regarding ocean technology issues; 2) construct the foundation; 3) recover the failed source and check the drive cable; and 4) install the new projector and foundation.

Actions 1 and 2 will occur in conjunction with the construction of the transducer, completed by 31 May 1987. Items 3 and 4 will occur at the same time (as presently planned) in that the failed transducer and the new installation will be carried out concurrently with one ship deployment. If available, a NOSC ship resource, on site at Oahu, will be used for the services.

3. Recovery of Failed Source

It appears that recovery of the HX-137 can be carried-out just prior to installing the new projector. However, further analysis may indicate the need to recover the failed source earlier in order to evaluate the quality and status of the existing cable. Therefore, a contingency plan, to use the existing NOSC ship resource to recover the HX-137, is being developed.

4. Dry End System

A new power amplifier and matching transformer will be required. These units may be available from Navy stock; or are available from commercial sources as an alternative. Units will be acquired and installed by NOSC early in the June 1987 time-frame.

5. Long Term Plans

At the completion of the recovery of the failed source and installation of the new source, operation and control of the new source will be turned over to NOSC who will operate and maintain the new system.

Early in FY-88, another complete transducer, foundation and wet-end transformer, will be acquired as presented in the initial analysis and plan. This is part of the resources required to keep the source operating on a continuing basis without major interruptions. The transducer/foundation should be recovered and replaced on a 12-month maximum refurbishment cycle. The recently retrieved transducer will be returned to Argotec for refurbishment and an analysis of the seals, coils and body condition. This action will help evaluate long term design issues for moving coil transducers, and keep source current.

6. Milestone Plan

To summarize the actions and time-frames for this project, a brief Milestone Chart is attached to help explain when the various tasks will be carried out.

7. Risk Areas

a. Long-term moving coil operation -- very little experience

b. Condition of existing cable -- usability not known, but local measurements indicate cable is satisfactory

c. Recovery of existing HX-137 -- after 7 years of installation, foundation and recovery bail may be eroded and weakened.

Budgetary Estimates

FY-87 Costs

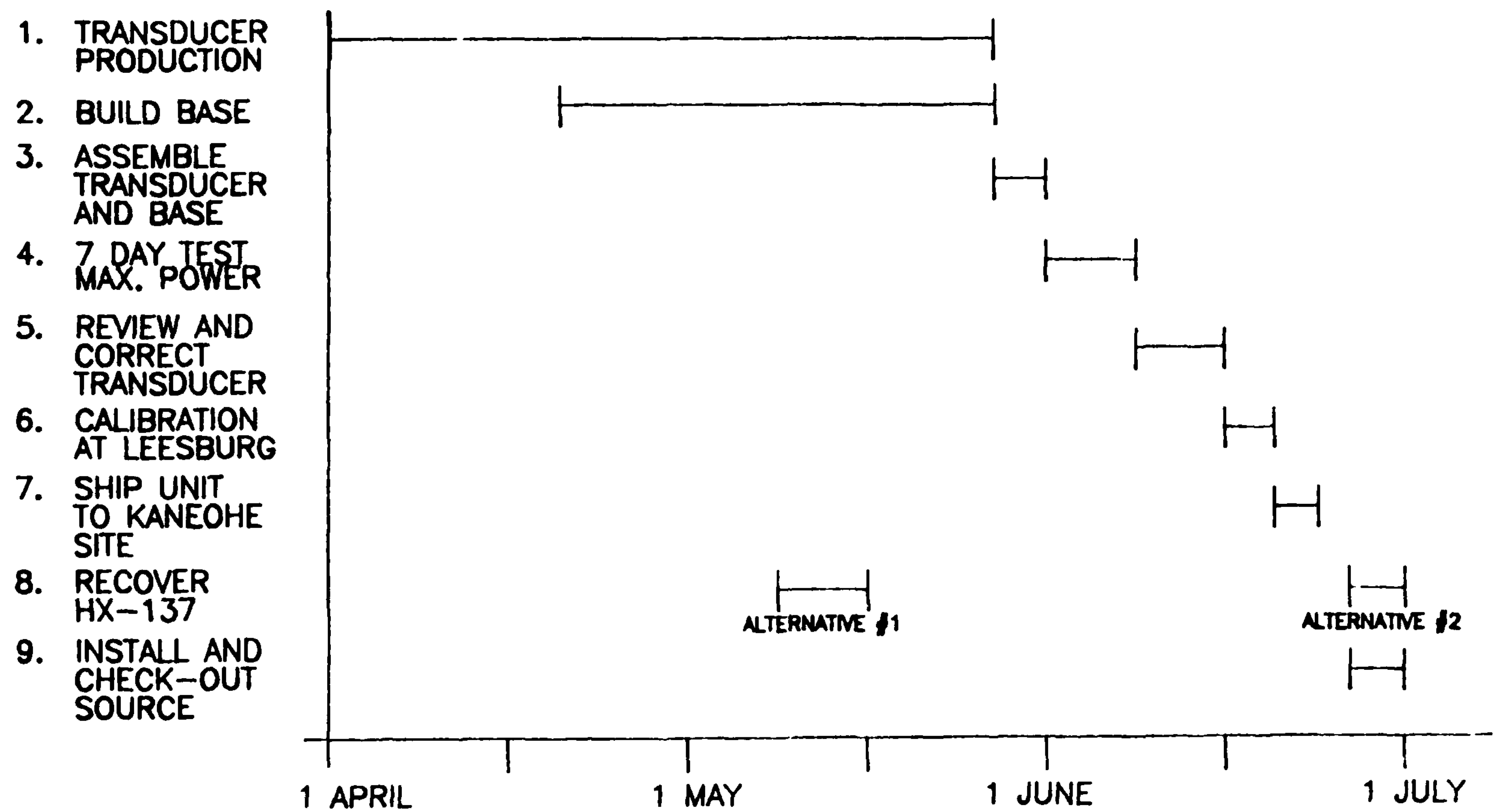
\$165.8K	One-time Cost and First Transducer
22.5K	Recover HX-137
77.7K	Engineer Base, Install Transducer
\$266.0K	(NOTE: Actual costs were approximately \$350K due to XFMR failure and design changes.)

FY-88 Costs

\$112.8K	Production of Second Transducer
25.3K	New Foundation
12.0K	Recover and Install New Unit
\$150.1K	

FY-89 and Beyond

\$ 20K (Typical) Recover and Install - Refurbish Recovered Unit



KANEOHE SOURCE REPLACEMENT MILESTONE CHART

APPENDIX D

PARTICIPANTS IN KANEOHE SOURCE REPLACEMENT

1. James D. Pugh, NOSC Code 7302, 14 December 1986; "Status Report: Kaneohe Acoustic Projector Replacement and Repair" (Copy Attached)

2. Al Tims and Mark Young, Naval Research Laboratory, Underwater Sound Reference Detachment; Orlando, FL (305) 857-5100; Personal Communication on 11 March 1987.

3. Mr. Bernie Willard, Chief Engineer; Argotec, Inc.; Fort Lauderdale, FL (305) 584-7900; Personal Communications on 11 and 12 March 1987.

4. Mr. John Spiesburger, U.S. Navy Post Graduate School; Monterey, CA (408) 646-3226; Personal Communication on 9 March 1987 (At Woods Hole, MA. (617) 548-1400 x 2288).

5. Mr. Jim Pugh (NOSC Code 7302; San Diego, CA (619) 225-2157), and Mr. Francis Burns (Transducer Consultant) (619) 454-0880. Personal Communication on 9 March 1987.

6. Bob Jacob, Planning Systems Incorporated (703) 734-3400; Personal Communication on 9 March 1987.

7. Mr. Brad Holmes, Honeywell Corporation; Seattle, WA (206) 356-3018; Personal Communication on 11 March 1987.

8. Mr. Joe Percy, NOSC; San Diego, CA (619) 225-2970; Personal Communication on 17 March 1987.

9. LT Eric Holmstrom, COMOCEANSYS-PAC (808) 472-8480/8797; Numerous Personal Communication.

10. Mr. John Dixon, Tracor Marine; Fort Lauderdale, FL (305) 463-1211; Numerous Personal Communications.

11. Mr. Harry Chalmers, NOSC, Hawaii Laboratory (Manager, SSP KAMALINO) (808) 254-4454.

12. Mr. Lance Remick and Mr. Roger Bucher, Engineers at NOSC, Hawaii Laboratory (808) 254-4324 and 4459, respectively. Provided Engineering Support for Electronic Systems.

13. Dave Small, NAVOCEANO Code 6000 (made original installation, personal communications).

14. Linda Ovenden, ONR Contracts

APPENDIX E

OPERATIONAL PLAN — KANEOHE PROJECTOR REFURBISHMENT

Tracor Marine

OPERATION PLAN

KANEOHE PROJECTOR REFURBISHMENT

Submitted to:

Argotec, Inc.
3650C Hacienda Boulevard
Fort Lauderdale, Florida 33314

Submitted by:

Tracor Marine, Inc.
P.O. Box 13107
Port Everglades Station
Fort Lauderdale, Florida 33316

Report No. 87-701251-1

July 1987

Tracor Marine

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1. Overview

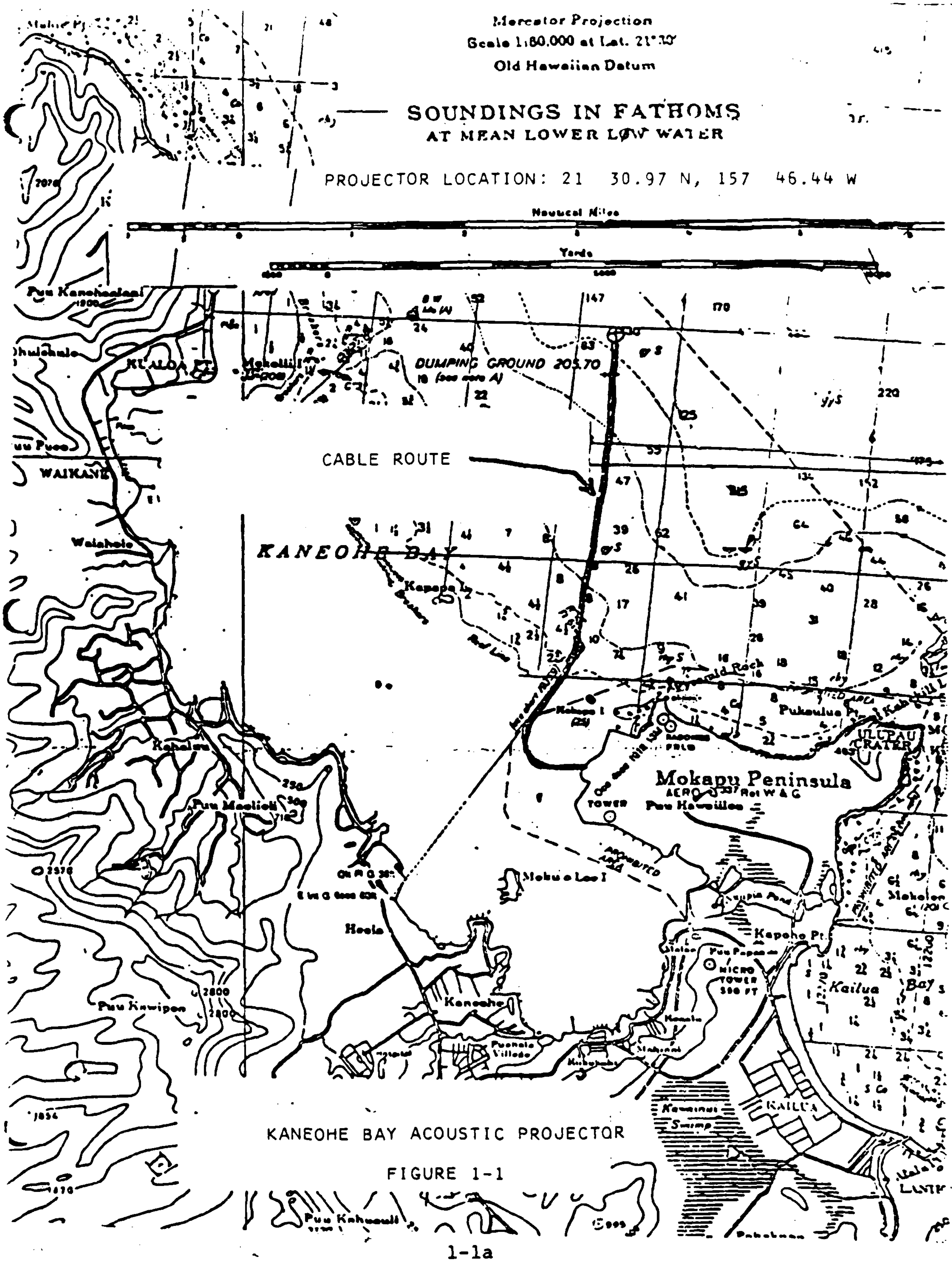
The U.S. Navy maintains an acoustic source in 600 feet of seawater (fsw) just outside Kaneohe Bay on the island of Oahu, Hawaii, as seen in Figure 1-1. In the fall of 1986, the source failed. Tests indicate the cable running from the Naval Ocean Systems Center (NOSC) facility on Mokapu Peninsula to the projector is in satisfactory condition. No response can be elicited from the projector. The projector is considered faulty, probably requiring major refurbishment.

In May of 1987 the NOSC SSP KAIMALINO supported a remotely operated vehicle which attached 1,000 feet of 1/2 inch diameter wire rope to the projector structure. The wire rope was terminated with a small chain anchor and flaked out along the bottom with a 600 foot length of 3/8 inch diameter polypropylene. A second chain anchor was used to drop the polypropylene bitter end to the bottom.

Argotec, Inc., is presently building a replacement projector. Tracor Marine is building a replacement projector stand. The plan for replacing the existing faulty projector and stand is given herein. The approach is based upon safety, careful consideration of the tasks to be accomplished, engineering analysis, previous experience, utilization of GFE wherever possible, and the established budget.

As with all sea operations, no plan remains unchanged. The primary goal of this report is twofold:

1. General plan of action
2. Learning curve acceleration for project personnel.



KANEOHE BAY ACOUSTIC PROJECTOR

FIGURE 1-1

1.2 Schedule

The project schedule is as follows:

	Project Day	Estimated Calendar Day
Transit Personnel	1	July 9
Mobilize Operations Vessel	2	July 10
Conduct At-sea Operations	3	July 13
Demobilize Operations Vessel	4	July 14
Transit Personnel Return	5	July 15

Mobilization Tasks

Mobilization tasks include the following:

- Load and tie down projector assembly.
- Load and secure system rigging equipment.
- Load and secure subsurface float.
- Establish Miniranger navigation.
- Check line counter of starboard roller assembly.
- Pull test winch A, B and crane to 6000 pounds.
- Load and check test and splicing equipment.
- Check hacksaw blades, vulcanizing tape and scrap hose (extra stock).
- Check radio communication to shore side facility.
- Rig NOSC grapnel, 20 foot length of 1-2 inch drag chain, swivel and 2000 foot length of 3/8 inch nylon line.
- Load tensiometer or spring scale.
- Establish dive station including ladder.
- Load food for full day operations.
- Check weather reports.
- Load winch A.
  - leader wire
- Load Winch B.
  - leader wire (bottom)
  - 1000 feet 1/2 inch galvanized wire rope (replacement recovery line)
  - 2000 feet 3/8 inch nylon grapple line (top).

Estimated At-sea Operations Schedule

0530	Crew and project personnel on board.
0600	Depart dock, chow en route.
0630	Miniranger navigation tower RT power up (en route).
0700	On station, check stationkeeping ability.
0730	Grapple rig on bottom, beginning drag.
0800	Dragging down grapple trackline.
0830	Wire rope snared in grapnel, beginning lift.
0900	Polypro removed, wire rope end attached to winch drum.
0930	Slack wire rope inhauled; beginning projector lift; vessel maneuvering down recovery trackline.
1000	Projector on deck, stopper signal cable.
1030	Begin cutting existing cable, mount on stand.
1100	Cut back three feet of armoring for pigtail breakout.
1130	Strip armoring off, separate and clean conductor wires.
1200	Chow.
1230	Conduct cable continuity and TDR test.
1300	Splice signal and ground of cable and transformer pigtails.
1330	Continue splicing.
1400	Conduct cable continuity and TDR test.
1430	Low level transducer power-up on deck, impedence check.
1500	Secure pigtail service loop; ready new projector for overboarding.
1530	Overboard new projector; workboat streams subsurface float (SSF) line; ops vessel begins trackline transit.
1600	Overboard test hydrophone; confirm projector operation.
1630	Projector on bottom; final confirmation of source level.
1700	Begin laying out 1000 foot grapple line; workboat sliplines SSF.
1730	Lower wire bitter end on polypro; vessel breaks away.

1800 Return to port.

1830 Chow (en route).

1900 Alongside dock.

Demobilization Tasks

- Unload faulty projector.
- Recover navigation gear.
- Unload winch drums.

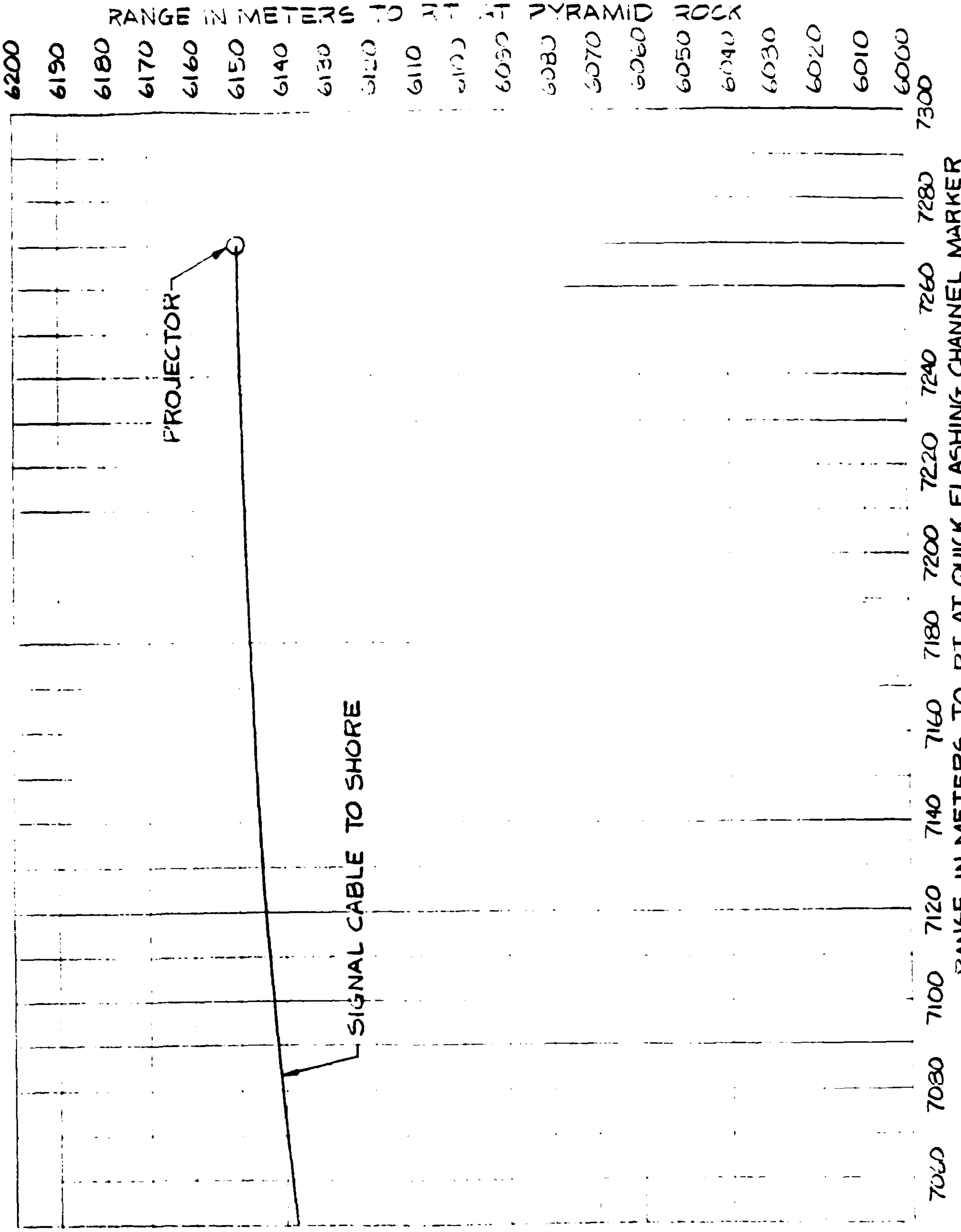
1.3 Navigation

Primary navigation will be radio based in range/range mode utilizing a Motorola "Mini-Ranger". One radio transponder (RT) will be stationed on Pyramid Rock. A second RT will be affixed atop the 23 foot high tower Quick Flashing Channel-Range Marker at the entrance of Kaneohe Bay.

The available unit for the project is an older model that provides discrete ranges only. Tracklines will have to be navigated manually with no visual display for the helmsman.

Presently available navigational information for the in-situ projector, cable and grapnel wire is limited. It is expected that constant monitoring of wire and cable fleeting angles will be required. Navigational data will be edited and verified in the field where possible.

Figure 1-2 shows the predicted range/range grid in the location of the projector. Relative accuracy is estimated at ± 50 feet, although greater deviation is possible. Absolute geodetic accuracy is not known. Commonly accepted coordinates for the projector are 21°30.97N and 57°46.44W.



MINIRANGER NAVIGATION GRID

FIGURE 1-2

GFA 7-7-87

2.0 EQUIPMENT

2.1 Operations Vessel

The operations vessel for the refurbishment is the SSP KAIMALINO homeported at Kaneohe Bay, Oahu, Hawaii. The KAIMALINO is an 89 foot Small Water Plane Area Twin Hull (SWATH) vessel displacing 217 long tons. Figure 2-1 provides specific vessel informaton as well as cutaway and general views. The SSP KAIMALINO is managed by Naval Ocean Systems Center-Hawaii Laboratory. Deck layout for the refurbishment will include two single drum winches portside and knuckleboom crane and overboarding rollers starboard side, as shown in Figure 2-2.

2.2 Knuckleboom Crane

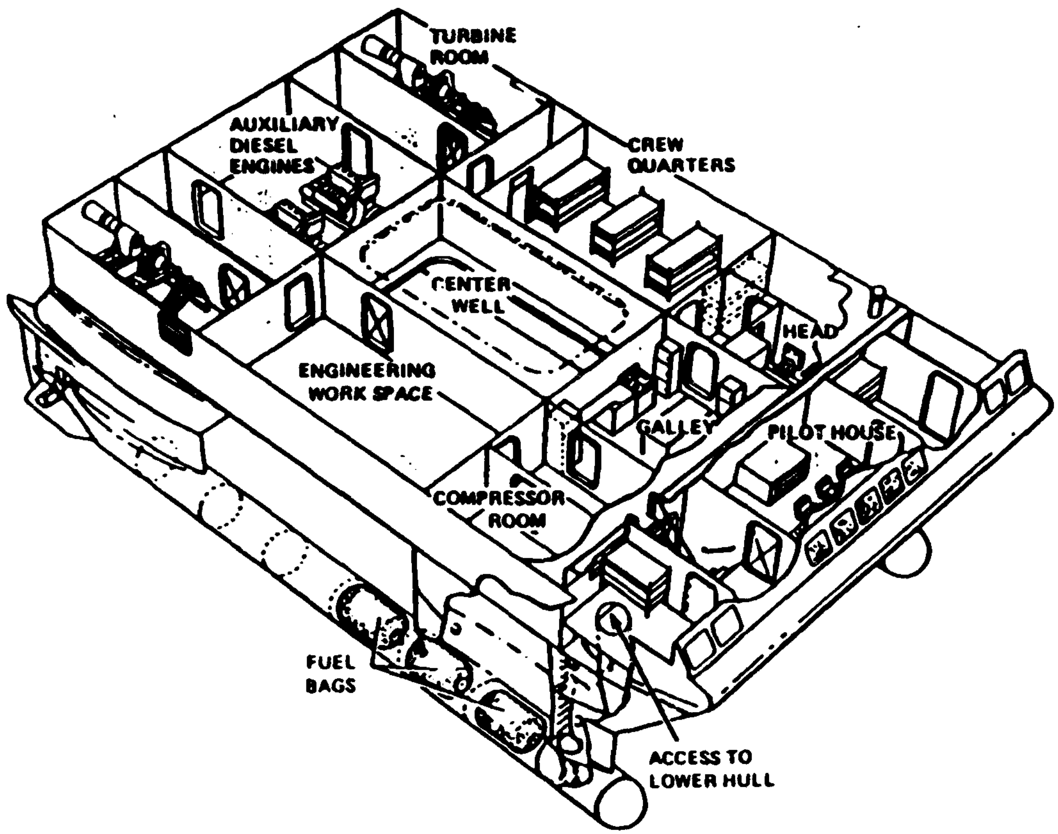
The SSP KAIMALINO crane is midjointed, double inhaul winched, and hydraulically powered. It is rated for approximately 1,500 pounds at 24 feet and 6,000 pounds at 6 feet.

2.3 Deck Winches

The SSP KAIMALINO will be premobilized with two hydraulically powered, single drum winches. The winches will be mounted on the deck portside and amidships one behind the other. The forward winch will be denoted as winch alpha (A). The aftermost winch is denoted as winch bravo (B). Both winches are rated 7,500 pounds pull-bare drum and 5,000 pounds pull-full drum.

2.4 Projector and Stand

The replacement projector and stand are shown in Tracor Marine Drawing #D0701251-001. The air weight of the assembly is approximately 3,000 pounds. Cable tension at the surface is estimated to be 600 pounds. Total overboarding weight will be the summation; 3,600 pounds.



Kaimalino CHARACTERISTICS

Length Overall	88 Feet 4 Inches
Beam Overall	46 Feet 6 Inches
Well Dimensions	23 X 12.5 Feet
Draft (Normal):	15 Feet 3 Inches
Gross Payload	34.9 Long Tons
Mission Payload*	16 Long Tons
Main Propulsion	T64-GE-6B Turbines (2) 2204 HP Each
Auxiliary Propulsion	8V-71T Detroit Diesels (2)
Propeller System	Wilkinson Controllable Pitch, 4 Blade 6.5 Foot Diameter
Maximum Speed	24 Knots
Cruise Speed	15 - 18 Knots
Auxiliary Speed	0 - 6 Knots
Hydraulic Capacity*	60 GPM at 2,000 PSI
Electrical Capacity*	300 Kw, (480, 240, 120 VAC - 3 PH, 60 Hz)
Deck Area	3,400 Square Feet (with well covered)
Displacement	217 Long Tons
Berthing Capacity	10 Crew, 6 Scientists
Lower Hull Diameter	6.5 Feet

*Available for Customer Support Equipment

ANCILLARY EQUIPMENT

Sperry Doppler Speed Log (± 0.1 Knots Resolution)
Marconi Radar (0 - 36 Mile Ranges)
VHF, UHF, and HF Military and Civilian Frequencies
Depth Recording Fathometer (0-1250 Fathom Ranges)
Propeller Shaft Torque and Speed Indicators
Underwater Cameras and Observation Ports
Automatic Motion Control System (With Motion Outputs)
Mark-27 Gyrocompass
Wind Speed and Direction Indicators

Figure 2-1

SSP KAIMALINO
DECK LAYOUT

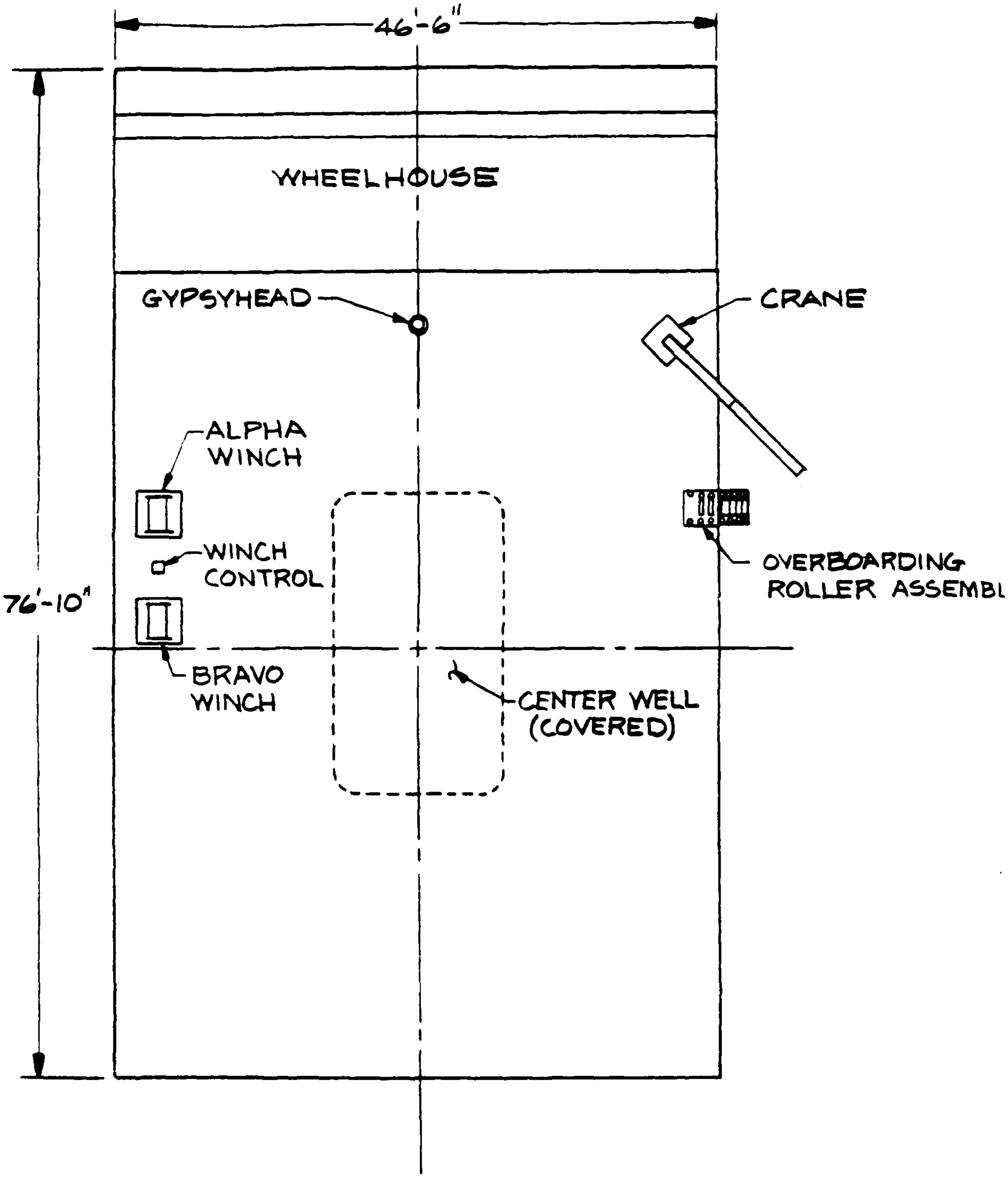


FIGURE 2-2

GFA 7-7-87

At the surface, the projector's pressure compensating air bladders will provide approximately 1,600 pounds of positive buoyancy. The resultant negative downward force at the surface is 1,400 pounds.

As the projector is lowered, the volume of air decreases with depth. Before the projector reaches 100 feet of seawater, the positive buoyancy of the bladders will be reduced to one-fourth of the original force which is approximately 400 pounds positive.

The shore cable will be led over the cable fairing and clamped to it using U-rods and backing nuts. Both the grapnel line and the subsurface float line will be rigged with in-line swivels and secured to a 20 foot pendant. The other end of the pendant will be pinned at the projector stand.

The projector's stability will allow it to land and remain standing in currents up to two knots while on bottom slopes approaching 30°.

The installed underwater system is shown in Tracor Marine Drawing #D701251-004. It is comprised of the projector and stand, shore cable, grapple line and subsurface float.

3.0 RECOVERY OPERATIONS

3.1 Grappling

The 1000 foot length of 1/2 inch wire rope previously attached and laid out over the bottom by the SSP KAIMLAINO and a remotely operated vehicle will be grappled. The grappling rig consists of 2000 feet of 3/8 inch nylon shackled to approximately 20 feet of one to two inch chain. A sliding prong type grapnel will be shackled to the end of the chain.

The grapnel line previously loaded on winch B will be reeved through a wide mouth six inch throat snatch block hung from the crane starboard side as shown in Figure 3-1. The grapnel will be overboarded and lowered to the bottom.

A tensiometer spring scale will be rigged to a snatch block riding on the grapple line. The scale will be cinched toward the deck until a mid-scale reading is obtained as shown in Figure 3-2 and restrained with pendants and shackles.

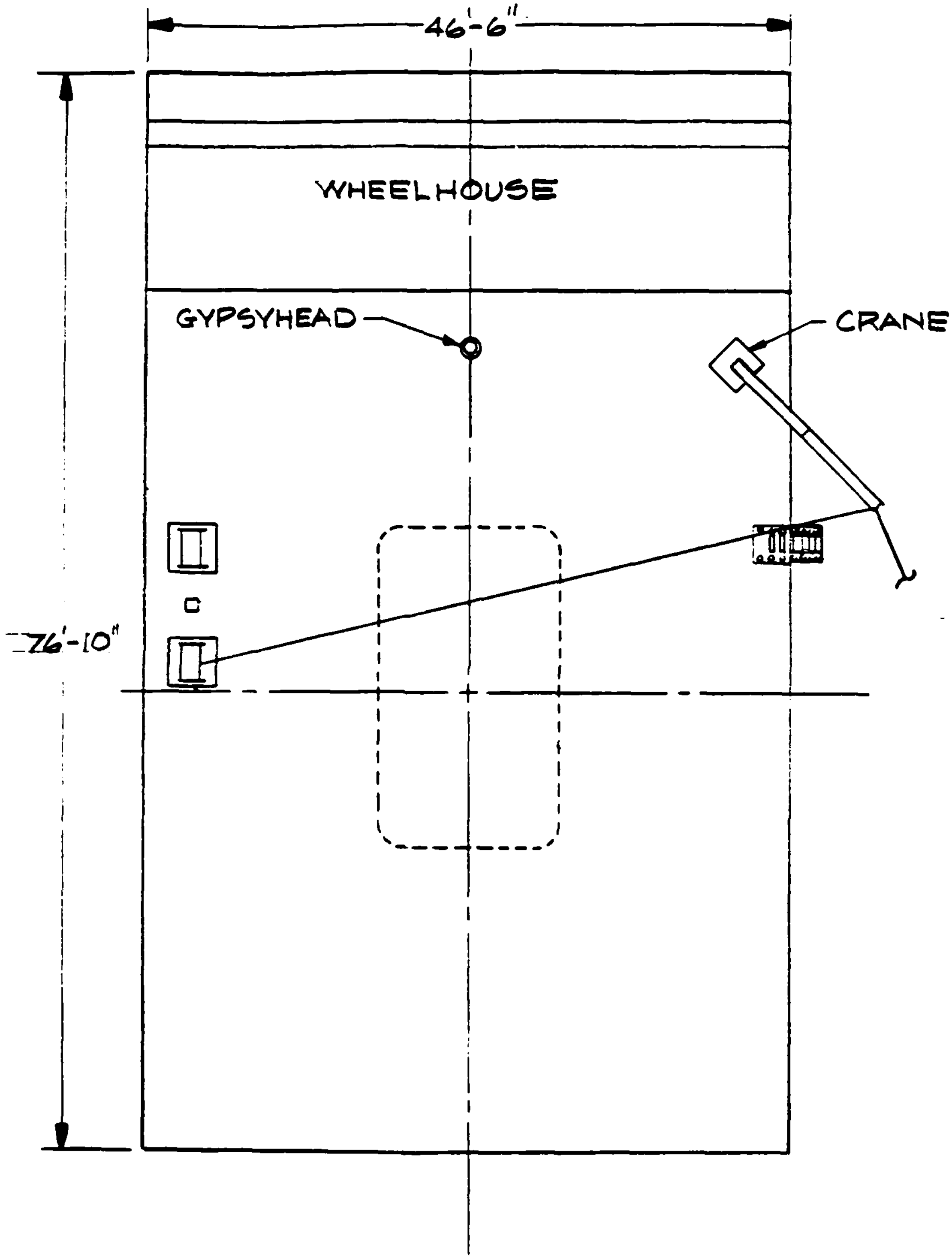
Once the tensiometer is rigged, the vessel is ready to begin dragging. Figure 3-3 shows the first dragging trackline. Successive drag tracklines will be determined on site, depending upon currents, sea conditions, grapple line scope, etc.

The spring scale will be closely monitored during all runs. When tension increases indicating entrapment of the grapple line, the vessel will be stopped, position noted and recovery begun.

3.2 Inhaul

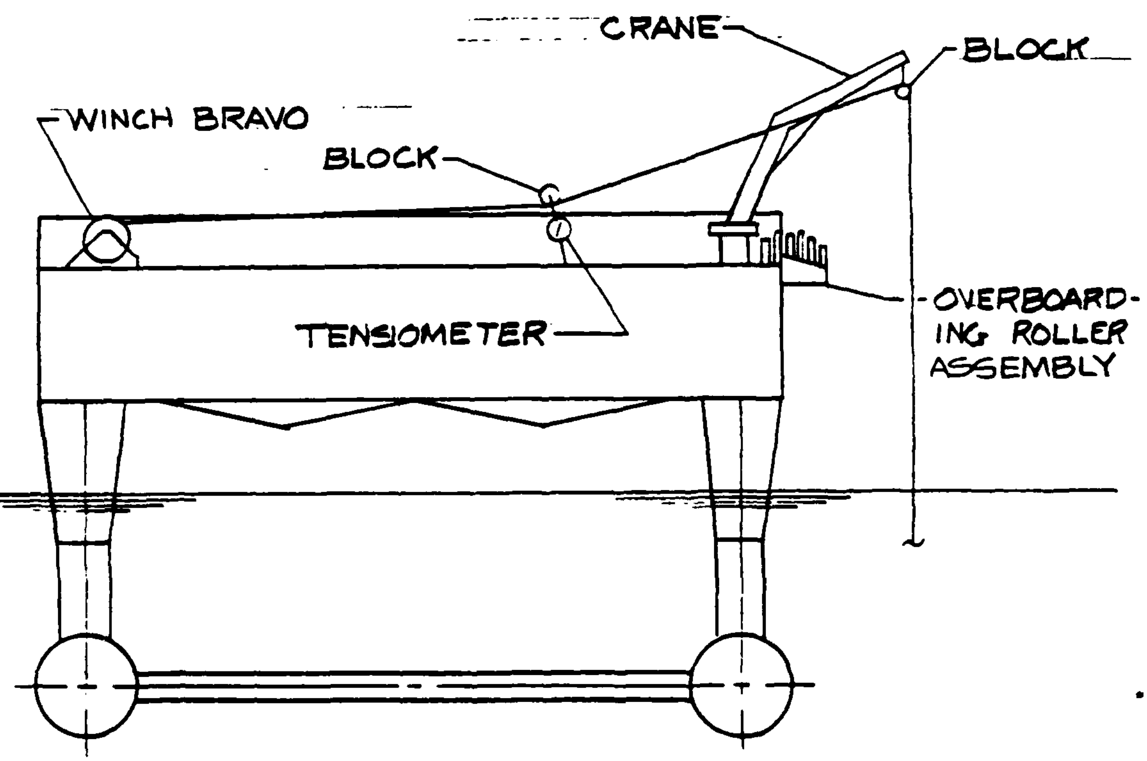
The vessel position noted at grapple line entrapment will be adjusted for heading and payout to estimate the grapnel position. As grapple line is inhauled, the vessel will maneuver toward this position.

SSP KAIMALINO



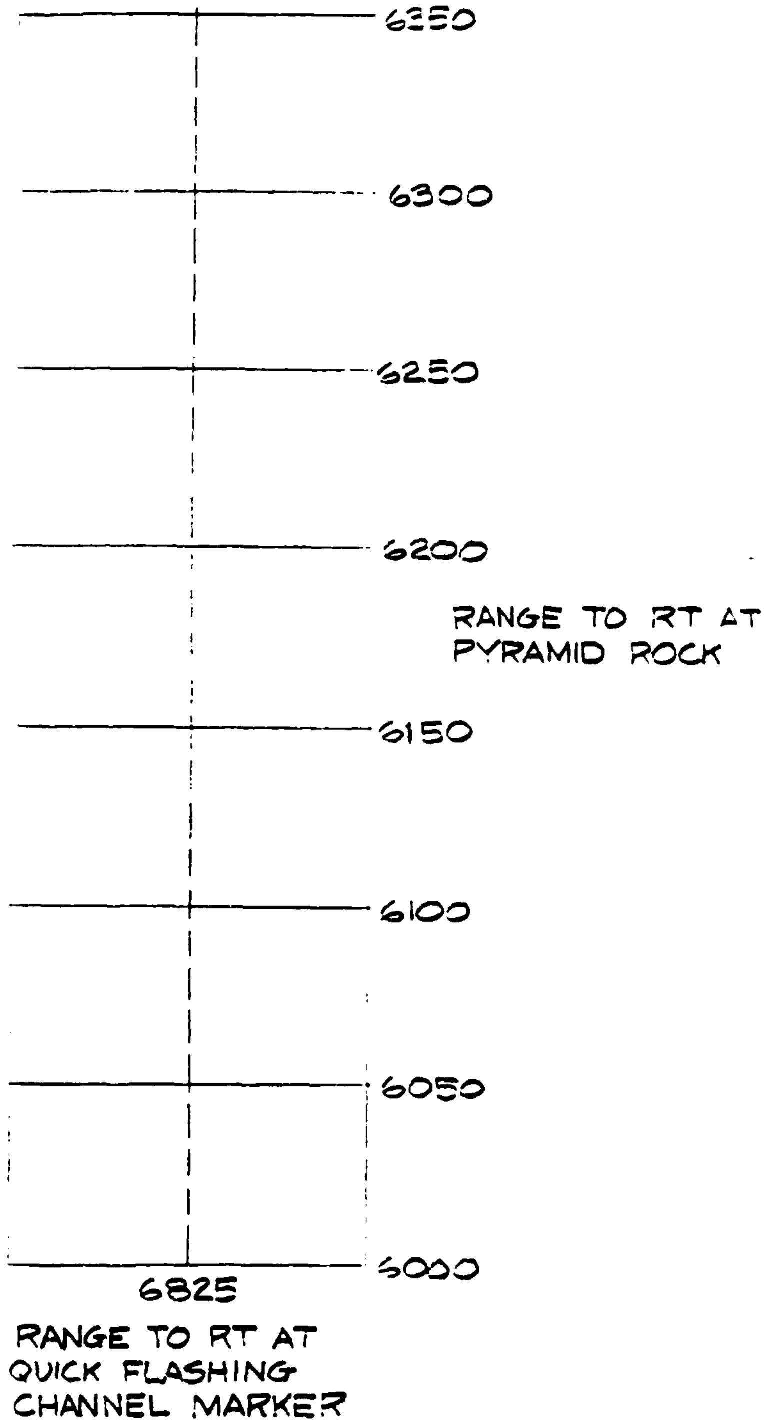
SNATCH BLOCK ON CRANE USED
TO OVERBOARD GRAPPLE LINE
FIGURE 3-1

GFA 7-7-87
NTS



VIEW SHOWING SPRING SCALE OR
TENSIOMETER RIGGED BETWEEN SNATCH
BLOCK RIDING ON GRAPPLE LINE AND DECK PADEYE
FIGURE 3-2

GFA 7-7-87
NTC



GRAPPLE TRACK LINE
RANGE IN METERS
FIGURE 3-3

GFA 7-7-87
NTS

Here and during all remaining operations, line angles into the water will be closely monitored and correlated with positioning data. All remaining vessel operations will be conducted at dead slow speeds to help minimize risk of line overloading and fouling.

When grapnel and chain approach the surface, the tensiometer and riding block will be released and cleared away. The crane will transfer the load to the roller assembly and the crane snatch block released.

Clearance of the hardware past the submerged pontoon hull will be checked and the vessel listed to starboard if necessary.

The grapple chain will be inhauled over the roller. If required, the crane will be used to swing the grapnel on board. Once on deck, the polypropylene or wire rope recovery line (which-ever has been recovered) will be stoppered off and secured to a deck padeye, the grapnel and chain removed, and the grapple line attached to the recovery line.

Inhaul will continue until one of the two 300 pound chain clumps breaks the surface. The crane will recover the clump on deck.

If the clump is the polypropylene bitter end clump, inhaul will continue until the second clump is reached. If the clump is at the connection between the polypropylene and the 1/2 inch wire rope, the clump will be craned on board and the loaded recovery lines stoppered off and secured to deck padyes. Alpha winch will be rigged to the 1/2 inch wire rope and Bravo winch will take charge of the polypropylene.

Once the polypropylene is fully recovered, the 1/2 inch wire rope can be pulled taut in preparation for the projector lift. Prior to the lift, wire angles and navigation positions will be correlated for agreement. Additionally, the roller assembly payout counter will be reset.

Begin 600 foot projector lift. Vessel will maneuver down recovery trackline as shown in Figure 3-4.

For contingency, additional lift power can be obtained by rigging one of the crane winches through a snatch block mounted on Alpha or Bravo winch and back to a chain or carpenter stopper on the recovery line.

Once the projector reaches the surface, a swimmer will attach the crane hook and taglines. When the swimmer clears the water, the projector is craned aboard.

The signal cable will be set in the starboard side roller assembly. One or two cable grips will be attached, depending upon load and heave, and shackled to deck padeyes.

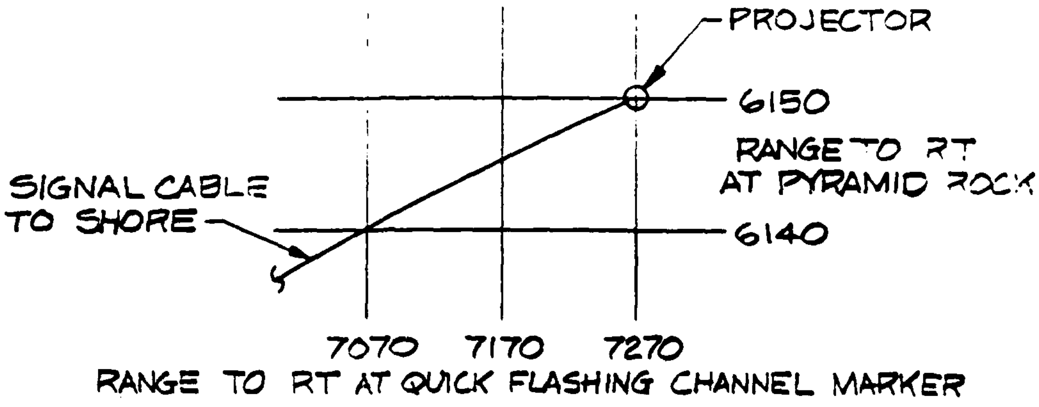
3.3 Projector Topside

Once on board, the cable to the recovered projector will be severed. The recovered projector will be moved to its storage position and the new projector moved next to the cable.

The cable's double armor will be hacksawed and stripped off over the last three feet. The cable center will be separated into two pigtails--center conductor and ground tape.

The pigtails will be spliced together with the step-up transformer pigtails. Vulcanizing-type tape and/or molded splices will be utilized. Vulcanizing tape and hose sections will be used to seal and protect the bared armor rods.

Tracor Marine



GRAPPLE LINE ON DECK	RT DATA
0	7270
50	7255
100	7240
150	7224
200	7209
250	7194
300	7179
350	7163
400	7148
450	7133
500	7118
550	7102
600	7087

Projector Recovery Trackline

Figure 3-4

Cable continuity, Time Domain Reflectometer (TDR) and impedance tests will be conducted on the cable prior to and following the associated splicing. Standard precautions with electrical equipment at sea will be strictly adhered to.

The cable will be placed over the projector stand cable fairing and bolted down with U-rods. Hose sections will be placed on the cable if necessary to prevent grounding cable armoring to projector stand.

While on deck, the projector will be subject to a low level power-up to confirm operation.

The new projector will then be readied for overboarding. The new length of 1000 feet of 1/2 inch galvanized wire on winch Bravo will be rigged to the swivel and the 20 foot pendant. The 20 foot pendant will be attached to the projector stand. The 490 foot 3/8 inch subsurface float wire will be rigged with a swivel and shackled to the 20 foot pendant. Finally, taglines and the crane hook will be attached.

3.4 Deployment

The 490 foot pendant is unreeled and made up to the subsurface float with a lazy shackle. The float is overboarded and a work boat takes charge of it using a 400 to 600 foot slip line. The work boat maneuvers with the sea to stream the 490 foot pendant away from the ship.

The crane picks up the system load and the cable grips are released. The crane then overboards the projector assembly and the load is transferred to winch Bravo.

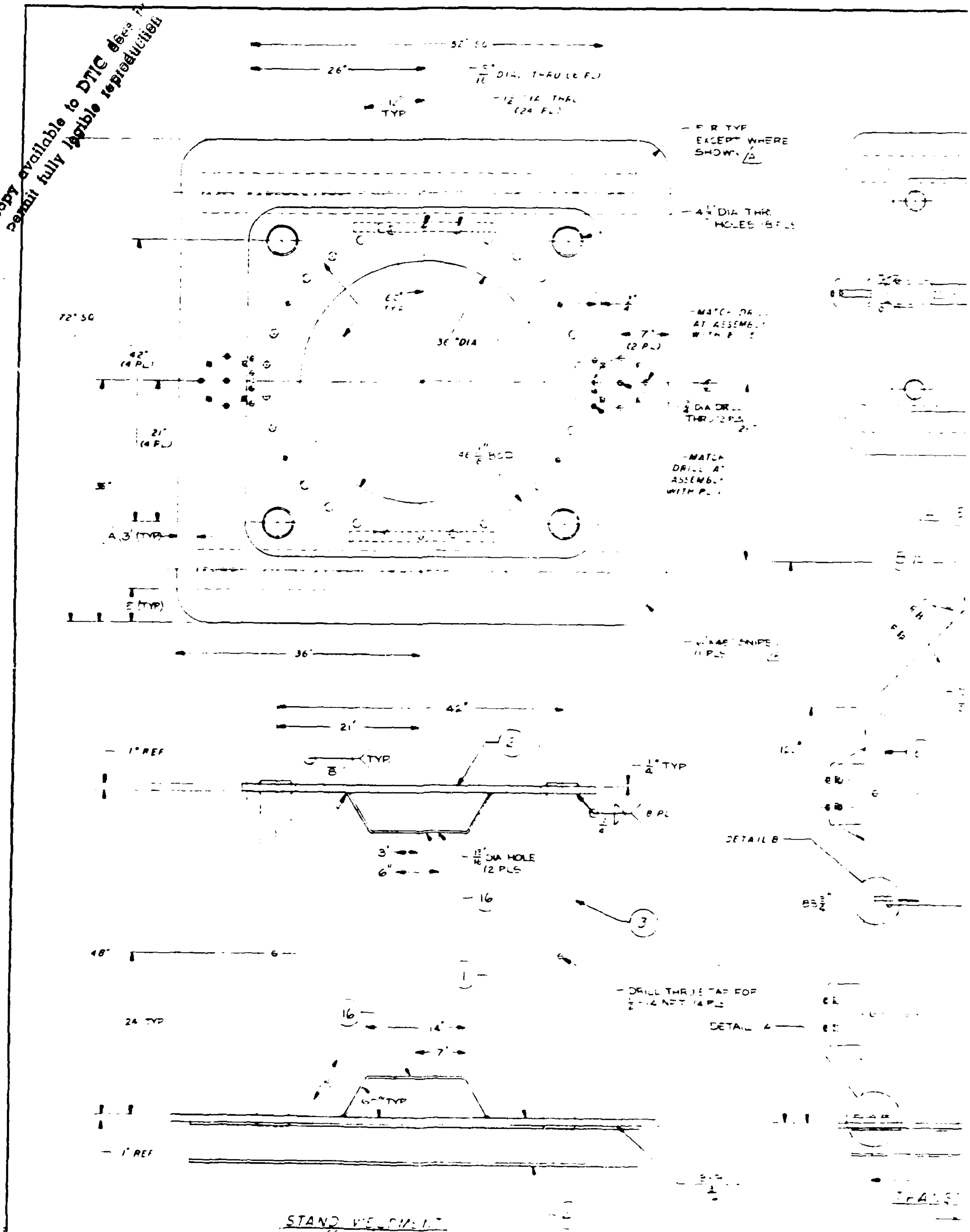
Winch Bravo is paid out lowering the projector as the SSP KAIMALINO returns back down the recovery trackline.

If a hydrophone test assembly is available, stops can be made to overboard the hydrophone and check for projector output.

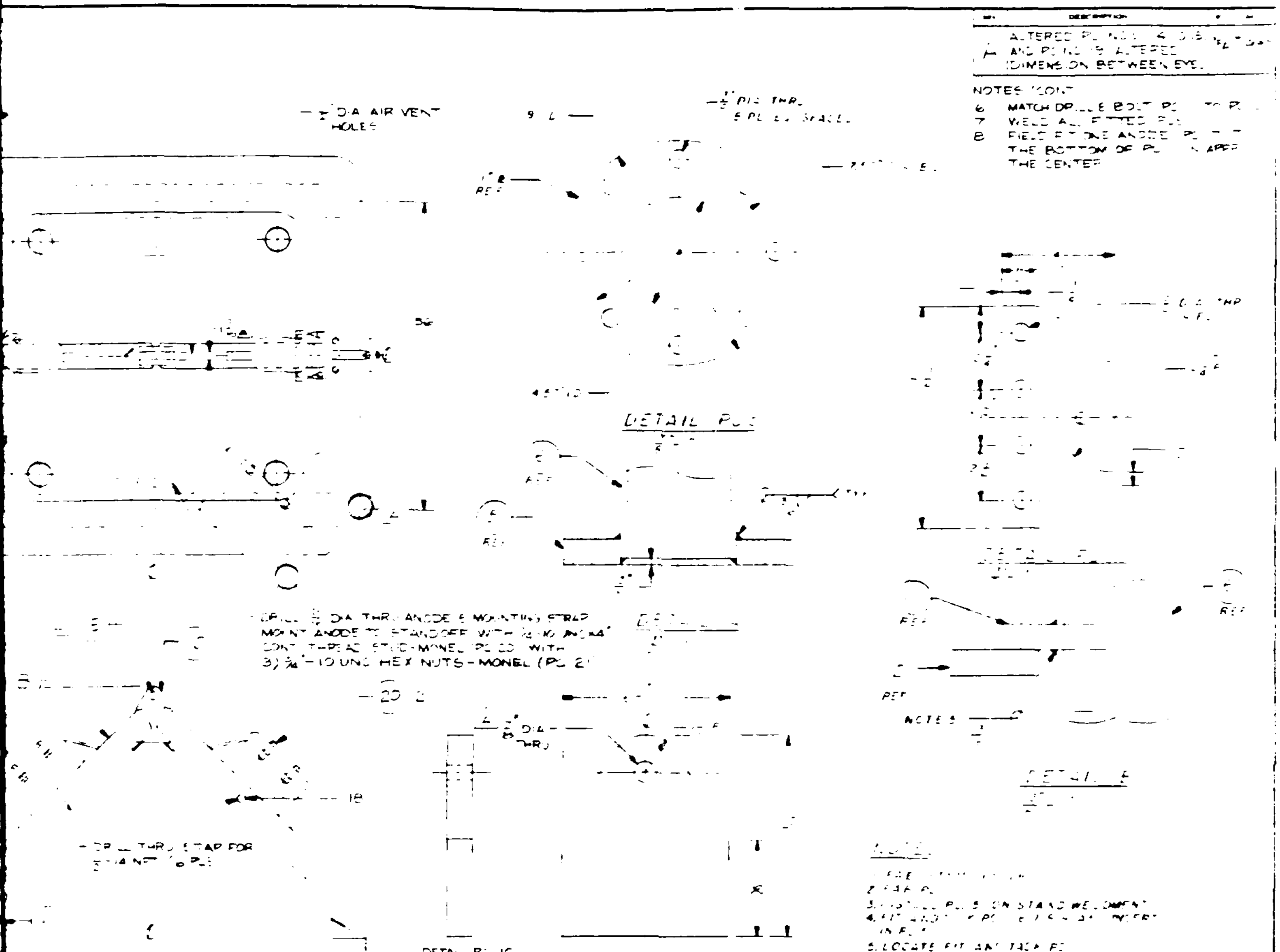
As the projector heads for the bottom, the work boat continues tensioning the 3/8 inch subsurface float line. As the projector approaches the bottom, the subsurface buoy submerges. The work boat retains control with the slip line until the projector is on the bottom and the SSP KAIMALINO clears the area.

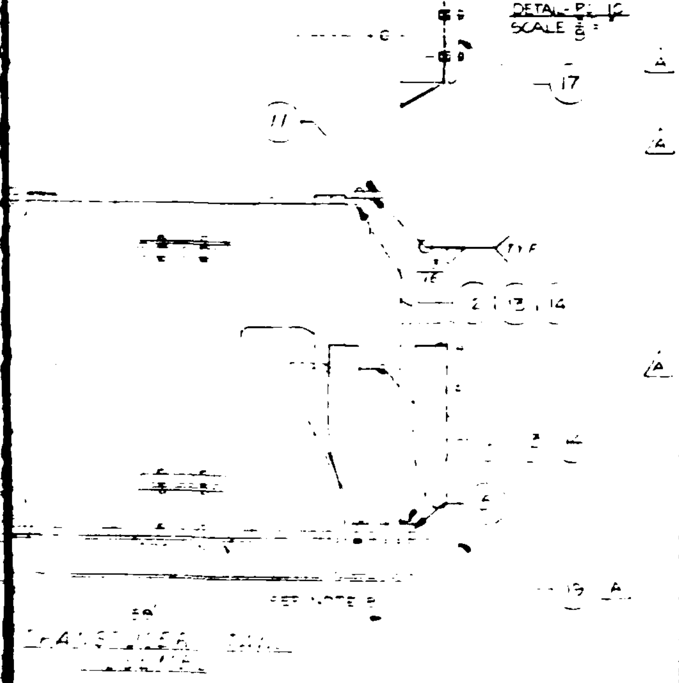
Once the projector is on the bottom, SSP KAIMALINO begins laying grapple line out over the bottom. Critical attention will be given to recording all navigational data during these operations.

The three hundred pound chain anchor is attached to the bitter end of wire rope as well as a new polypropylene lowering line. The wire rope bitter end is lowered to the bottom and the polypropylene is attached to a second anchor and dropped over the side.



26"
TYP
EXCEPT WHERE
36"DIA
72" SQ
42"
(4 PL)
21"
(4 PL)
(TYP)
36"
42"
21"
1" REF
TYP
DIA HOLE
12 PLS
16
3
DETAIL B
48"
24 TYP
16
14"
7"
60° TYP
1" REF
DETAIL A
STAND WELDMENT





21	66	NUT HEX	3/4 DIA - 10 UNC		MONEL
20	22	STUDS CONT THREAD	3/4 DIA - 10 UNC x 4 LG		MONEL
19		CABLE FAIRING PLATE ASSEMBLY	TRACOR MARINE		
18	10	ANODE SCREW PLUG	LEAD MARINE		
17		ANODE ZINC NOM WT 22	FED METALS	TAPERED	
16	10	ANODE BRACKET	1/4 x 1/2 FB x 26		AL 5086
15	1	BOLT, HEX HD & CASTLE NUT	7/8 DIA UNC x LG		
14	48	WASHER, FLAT	5/8 NOM.		
13	24	NUT, HEX	5/8-11 UNC		
12	24	BOLT, HEX HD	5/8-11 UNC x 3		MONEL
11	2	BRACKET	1" PL - 4 1/2" x 5 3/4"		
10	2	EYE	1" PL - 6 1/2" x		AL 5086
~~9~~		~~ELL 90°~~	~~4" IPS SCH 40~~		~~AL 5086~~
8	2	PIPE	4" IPS SCH 40 LG AS REQ		AL 5086
~~7~~	~~2~~	~~ELL 45°~~	~~4" IPS SCH 40~~		~~AL 5086~~
6	2	PIPE	4 IPS SCH 40		AL 5086
5	2	FLANGE	1" PL		AL 5086
4	2	BEAM WIDE FLANGE			
3	2	PIPE			AL 5086
2		PLATE			
1		PLATE			AL 5086
		TR			
PC NO	QTY	DESCRIPTION	SIZE / MANUFACTURER	CAT NO	REMARKS

BILL OF MATERIAL

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
ANGLES ±
2 PLACE DECIMALS ±
3 PLACE DECIMALS ±

Tracor Marine
P.O. BOX 13107
PT. EVERGLADES FLORIDA
33316

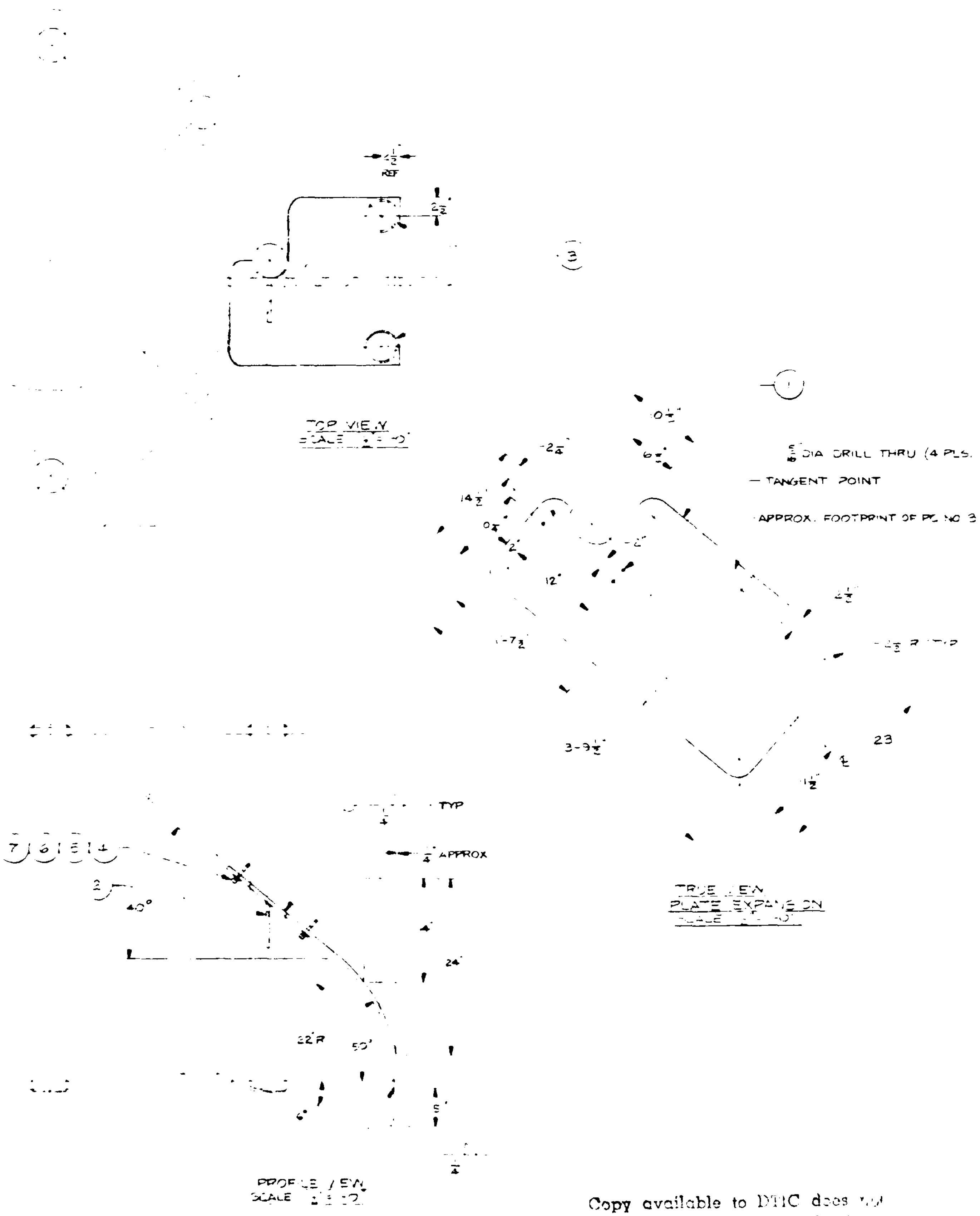
TRANSDUCER STAND
KANEOHE BAY PROJECTOR

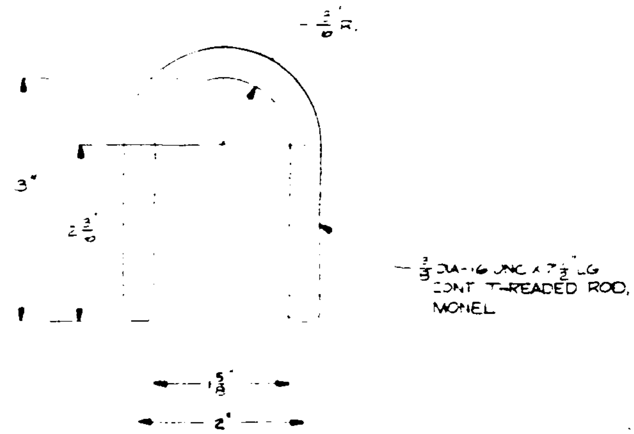
NEXT ASSY	USED ON

APPLICATION

Drawn / Checked / Engr / Approved

SIZE: D | CODE IDENT NO: 4D747 | DRAWING NO
SCALE | DATE | SHT


REF
TOP VIEW
3
DIA DRILL THRU (4 PLS.
— TANGENT POINT
APPROX. FOOTPRINT OF PC NO 3
12"
23
3-9½"
TYP
APPROX
40°
24"
22"R
50°
PROFILE VIEW
SCALE
TRUE VIEW
PLATE EXPANSION



DETAIL PC 4
SCALE 1:1

PC NO	QTY	DESCRIPTION	SIZE	MANUFACTURER	CAT NO	REMARKS
7	4	NUT, HEX	3/8" DIA-16 UNC			
6	4	LOCK WASHER	3/8" DIA NOM			
5	4	FLAT WASHER	3/8" DIA NOM			
4	2	CONTINUOUS THREADED ROD	3/8" DIA-16 UNC x 7 1/2" LG			MONEL
3	2	PIPE	4" PS-SCH 40 x 24" LG			AL 5086/6061
2	1	GUSSET	1/2" PL x 6 x 6 x 45°			AL 5086
1		PLATE	1/2" PL x 23" x 3'-9 1/2" LG			AL 5086
-		CABLE FAIRING PLATE WELDMENT				

BILL OF MATERIAL

Tracor Marine P.O. BOX 13107 PT. EVERGLADES, FLORIDA 33316

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/8
ANGLES ± 1°
2 PLACE DECIMALS ±
3 PLACE DECIMALS ±

CABLE FAIRING PLATE ASSEMBLY
TRANSDUCER STAND
KANEOHE BAY PROJECTOR

Drawn by F. ANDERSON

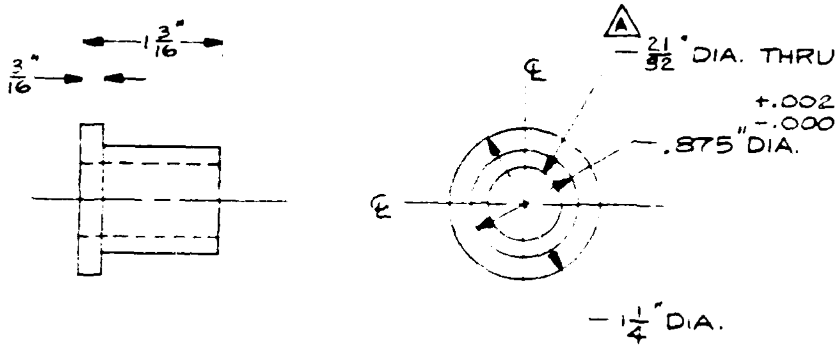
NEXT ASSY	USED ON
D70125I-001	D70125I-004

APPLICATION

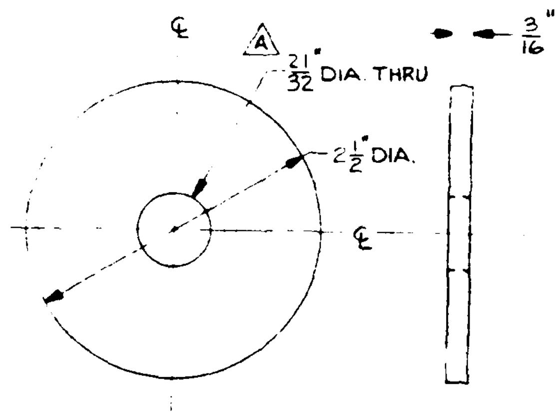
SIZE	CODE IDENT NO	DRAWING NO	REV
D	4D747	D70125I-002	-

SCALE NOTED | DATE 4 JUNE 1947 | SHEET

D70125I-002



(1) FLANGED BUSHING



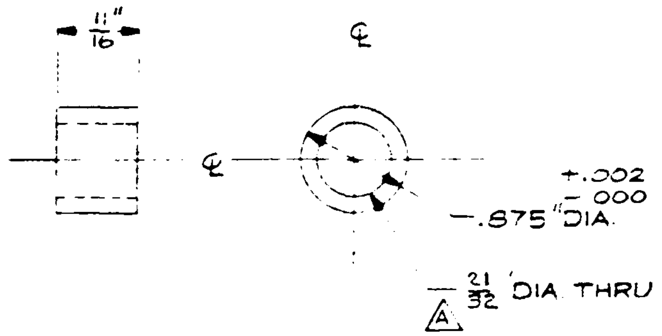
(3) WASHER

3	
2	
1	
PC NO	QT

0701251

NEXT

REV	DESCRIPTION	BY	DATE
A	CHG BORE TO 21/32 FROM 19/32	LLL	7/10/86



(2) BUSHING

REV A

C701251-003

PC NO	QTY	DESCRIPTION	SIZE	MANUFACTURER	CAT NO.	REMARKS
3		WASHER	2 1/2" DIA. x 3/16"			
2		BUSHING	7/8" DIA. x 11/16"			(OR EQUAL)
1		FLANGED BUSHING	1 1/4" DIA x 1 3/16"			GRAFITEX 113

BILL OF MATERIAL

TOLERANCES
UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
ANGLES ±
2 PLACE DECIMALS ±
3 PLACE DECIMALS ±

Tracor Marine
P.O. BOX 13107
PT. EVERGLADES, FLORIDA
33316

BUSHING DETAILS
KANEOHE BAY PROJECTOR

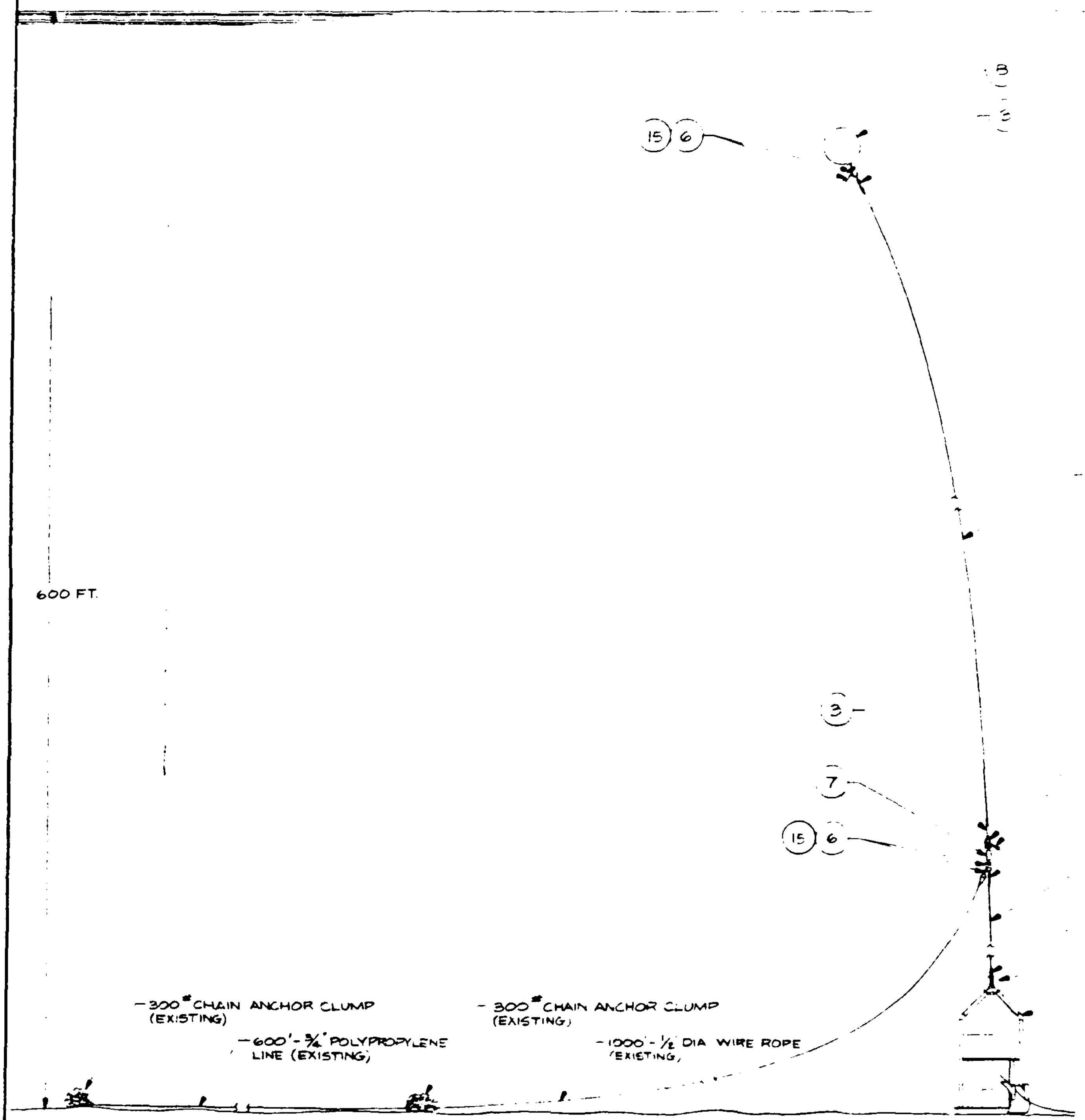
NEXT ASSY	USED ON
701251-004	D701251-004

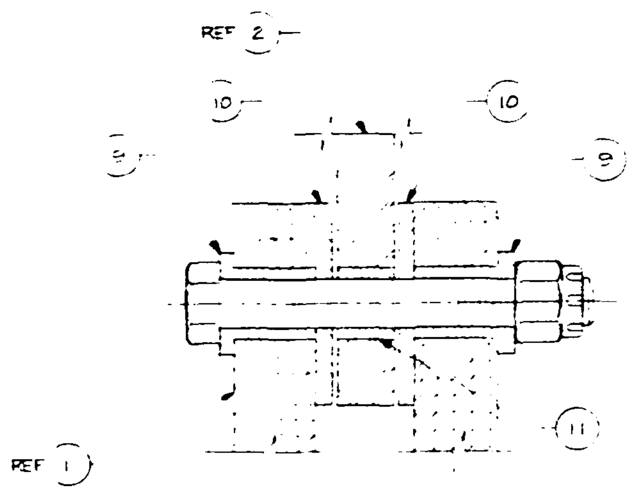
APPLICATION

Drawn: G F ANDERSON
Checked: WTJ
Engnr: WTJ
Approved: W T Jone

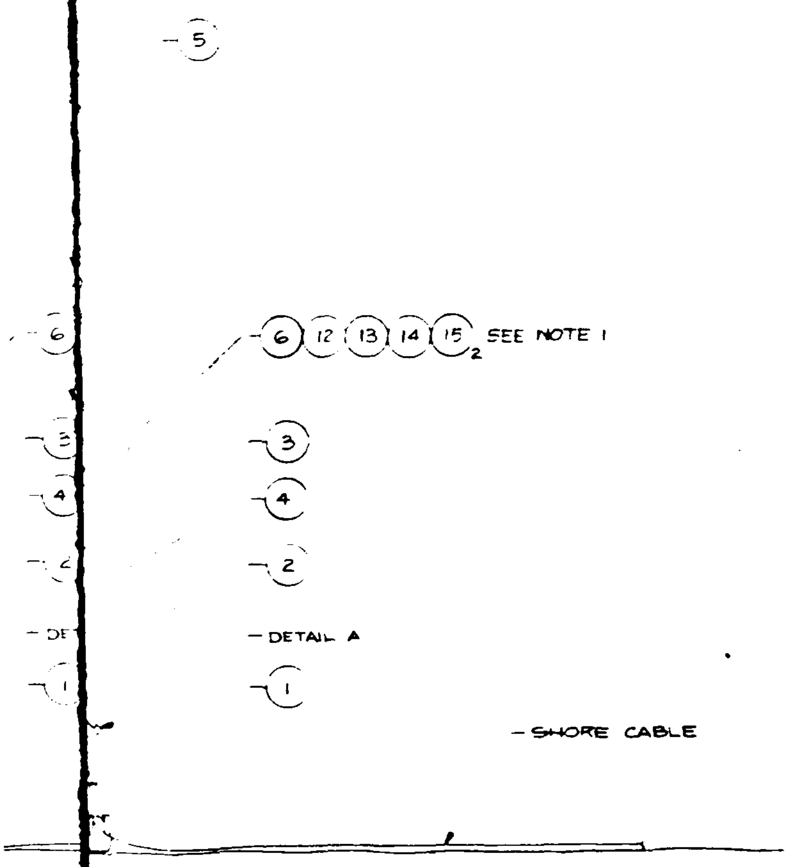
SIZE	CODE IDENT NO.	DRAWING NO.	Rev.
C	4D747	C701251-003	A

SCALE FULL | DATE 4 JUNE 1987 | SHEET 1 OF 1


15
6
600 FT.
3
7
15
6
-300# CHAIN ANCHOR CLUMP (EXISTING)
-600'-3/4" POLYPROPYLENE LINE (EXISTING)
-300# CHAIN ANCHOR CLUMP (EXISTING)
-1000'-1/2 DIA WIRE ROPE (EXISTING)



DETAIL A
SCALE 1:1



GENERAL NOTES:
1. REPLACE ALL COTTER KEYS IN SHACKLE BOLTS AND SWAGE SOCKETS WITH #10-24 x 1" RD HEAD MACHINE SCREW W/NUT & LOCK WASHER. (PC 12, 13, & 14)(10 PLS)

PC NO	QTY	DESCRIPTION	SIZE	MANUFACTURER	CAT NO	REMARKS
15	4	SHACKLE ANCHOR BOLT, TYPE	3/4"	CROSBY-LAUGHLIN	G2130	
14	10	WASHER, LOCK	#10 NOM			
13	10	NUT, HEX	#10-24			
12	10	MACHINE SCREW RD HD SLT	#10-24 x 1" LG			MONEL
11	1	BUSHING				PC 2
10	2	WASHER				PC 3
9	2	FLANGED BUSHING		TRACOR MARINE	DWG C701251-003	PC 1
8	1	SUBSURFACE BUOY	34" DIA			
7	1	SWIVEL, JAW & EYE	3 TON		3-S-3	
6	5	SHACKLE ANCHOR BOLT TYPE	7/8"	CROSBY-LAUGHLIN	G 2130	
5	1490'	WIRE ROPE	3/8" DIA 6x19 IWRC, [illegible] IMP. PLOW STEEL			GALV
4	20'	WIRE ROPE	3/8" DIA 6x19 IWRC, [illegible] IMP PLOW STEEL			GALV
3	3	OPEN SWAGE SOCKET	3/8"		S-50	
2	1	CLOSED SWAGE SOCKET	3/8"	CROSBY-LAUGHLIN	S-502	
1	1	PROJECTOR STAND ASSY		TRACOR MARINE	DWG D70125-001	

BILL OF MATERIAL

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
ANGLES ±
2 PLACE DECIMALS ±
3 PLACE DECIMALS ±

Tracor Marine
P.O. BOX 13107
PT. EVERGLADES, FLORIDA 33316

SYSTEM ASSEMBLY
KANEOHE BAY PROJECTOR

NEXT ASSY	USED ON
APPLICATION	

Drawn S F ANDERSON
Checked
Engr
Approved

SIZE	CODE IDENT NO	DRAWING NO
D	4D747	D701251-004

SCALE NONE | DATE 5 JUNE 1987 | SHEET ___ OF ___

Tracor Marine

29 July 1987

Mr. Joseph L. Collins
J-B Collins Associates, Ltd.
7823 Richfield Road
Springfield, Virginia 22513

Dear Joe:

It was a pleasure working with you on the Kaneohe Bay Projector Refurbishment. I especially appreciated your taking time to discuss aspects of the project not required for my involvement but that I found very interesting. I look forward to any future opportunities we might have for working together again.

Following are closing comments on several subjects pertinent to the project:

<u>RT Latitude/Longitude Transformations</u>

Transformations of the radio transponder (RT) coordinates obtained by John Speiceberger into Old Hawaiian Datum and WGS 72 are as follows:

- <u>WGS 84</u> (Speiceberger's GPS Data)

Pyramid Rock -	21° 29.7403N	21°29' 44.418"N
	157° 49.9702W	157°49' 58.210"W
QK F R 23 -	21° 27.7360N	21°27' 44.160"N
	157° 45.8130W	157°45' 48.780"W

- <u>Old Hawaiian Datum - Oahu Offset</u>

Pyramid Rock -	21° 29.9321N	21°29' 55.924"N
	157° 50.1261W	157°50' 07.568"W
QK F R 23 -	21° 27.9277N	21°27' 55.664"N
	157° 45.9689W	157°45' 58.133"W

- <u>WGS 72</u>

Pyramid Rock -	21° 29.7379N	21°29' 44.277"N
	157° 49.9702W	157°49' 58.212"W
QK F R 23	21° 27.7337N	21°27' 44.019"N
	157° 45.8130W	157°45' 48.780"W

If John has recently surveyed his West Coast receiver using GPS satellites, those coordinates would be in WGS 84. As such, he might fair better leaving the RT coordinates in WGS 84, calculating SSP KAIMALINO's position at projector touchdown in WGS 84 and obtaining great circle distance between the two WGS 84 based coordinates. Perhaps, his surveying unit has had the software previously installed.

Projector Depth

The vertical rigging attached to the projector had the following elevations over the bottom:

Item	Elevation Over the Bottom
Projector Bail	10'
20' pendant	30'
490' pendant	520'

After project implant on the bottom, the subsurface buoy visually appeared to be at a depth betwen 40 and 60 feet. This would put the projector at a depth betwen 560 and 580 feet.

The precision depth recorded (PDR) on the SSP KAIMALINO was inoperative at this time. The backup digital flasher fathometer generally confirmed this depth, although the depth resolution was too poor to improve depth accuracy.

The KAIMALINO group agreed to return to the site when their PDR was, again, operational and confirm the depth. A reminder might be required.

Navigational Data

Enclosed is a navigational data summary sheet showing pertinent RT ranges recorded as the projector system was reinstalled.

Operation Plan

Enclosed is one copy of the operation plan used for the refurbishment. At-sea changes to the plan were minor.

The initial trackline was refined after the SSP KAIMALINO Captain found better polypropylene line coordinates in his log book. The trackline followed started at A: 6800, B: 5800 and proceeded along the 6800 line until the B changed to 6050. The polypro grapple line was ensnared on the first drag at B equal to 5980.

The tensiometer was found to be unncessary because of the light loads encountered during grapnel dragging.

Tracor Marine

Polypropylene line capture by the grapnel was detected by a 10 to 15 degree change in the lifting line fleeting angle.

If I can be of any further assistance, please don't hesitate to call.

Sincerely,

TRACOR MARINE, INC.

John Dixon

John Dixon
Ocean Engineer

JDD/wb

Enclosure

Tracor Marine

KANEOHE PROJECTOR

Navigational Data Summary

- Refurbishment of 13 July 1987
- All ranges in yards
- Navigation provided by Motorola "Mini-Ranger" microwave radio positioning system operating in the range/range mode
- Radio transponders (RT) placed on 23 foot high tower denoted QK F R 23 at the entrance of Kaneohe Bay, and, Pyramid Rock Lighthouse

CABLE TRACKLINE

QK F R 23 Station A	Pyramid Rock Station B	Recovery Line on Deck
7270	6150	0
7249	6141	25
7225	6133	50
7204	6125	75
7184	6117	100
7163	6109	125
7143	6102	150
7125	6095	175
7105	6088	200

Projector Touchdown:

A: 7282 B: 6121

Wire Rope/Polypro Clump #1:

A: 6934-44 B: 6015

Polypro/Bitter End Clump #2:

A: 6741 B: 5931

Mark on Slipline:

A: 6661-46 B: 5916-05

Fleeting Angle: Approximately 70 degrees

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